THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 49 MAY, 1943 No. 5

A CRITICAL ANALYSIS OF THE ROENTGEN SIGNS OF INFANTILE SCURVY*

By RALPH S. BROMER, M.D.
Bryn Mawr Hospital
BRYN MAWR, PENNSYLVANIA

IN THE years which have passed since the discovery of the roentgen rays, diagnostic roentgenology has broadened to include many diseases. This is especially true in those pathological conditions affecting the skeleton in infants and children. It is well to review occasionally in critical fashion the accumulated diagnostic criteria in the literature of a subject and to retain that which withstands close and studious scrutiny and reject premises and conclusions found to be untenable in the light of clinical experience and investigative results. With this intent I have chosen to review, briefly, the roentgen signs of infantile scurvy. It is now fifteen years since I first reported the study of a series of 56 cases of this condition in a paper presented before this Society.[1] I attempted then to enumerate the roentgen signs of infantile scurvy and to arrange them in sequence so that four stages would show the progress of the disease as demonstrated in the roentgenogram. This was done with the purpose in mind of making the diagnosis less difficult for the roentgenologist and to lay emphasis on the diagnosis in early stages before the subperiosteal hemorrhages could be demonstrated.

The four stages described were, briefly, as follows:

First Stage. In the roentgenogram the changes present the smooth, transparent, ground glass appearance of the shafts, especially near the ends of the diaphyses; the dense zone of temporary calcification at the end of the diaphysis; the thinning of the cortex, sometimes called the "pencil point atrophy" and the dense ring about the epiphyseal center with the ground glass appearance of the cortex within it, similar to that shown in the diaphysis.

Second Stage. In this stage the zone of decreased density appears behind the zone of temporary calcification caused by the framework marrow zone, or the Trümmerfeldzone, or the scurvy zone, as it has been variously designated. In addition to this the first roentgenographic sign of hemorrhage beneath the periosteum may appear as shown by the formation of lateral spurs which project usually at right angles to the extremity of the diaphysis on either the outer or inner sides in the anteroposterior view.

Third Stage. Well developed subperiosteal hemorrhages are shown in this stage

* Presidential Address delivered at the opening of the Forty-third Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 15–18, 1942.

with the density of beginning calcification within them. The so-called epiphyseal separations occur most often in this stage. Barlow pointed out that these lesions should not be regarded as true separations of the epiphysis since the line of cleavage is not at the diaphyso-epiphyseal junction but involves the very limit of the diaphyseal extremity and they actually are infractions or fractures of the shaft.

Fourth Stage. In this stage the repair of the scorbutic lesions with absorption of the subperiosteal hemorrhages takes place. Progressive decrease in the breadth and length of the hemorrhages can be seen if serial examinations of the patients are made. But the roentgen signs of hemorrhage as shown by periosteal thickening can persist long after the clinical signs have abated and healing has begun. Other signs of healing are intensification of the zones of temporary calcification, gradual disappearance of the zones of rarefaction and increase in width of the dense ring surrounding the epiphyseal center. Some observers believe that the central area of ground glass texture remains stationary while the surrounding ring or zone becomes denser and broader as the epiphyseal centers increase coincidentally with the normal growth of the child's extremities. This small central area may persist for several years.

The fact was emphasized that if therapy is begun before subperiosteal hemorrhages are demonstrated in the roentgenograms the progression is from the two early stages to the final or healing stage without the occurrence of the third.

Does further experience and investigation as reported in the literature confirm such a classification into stages or is it unwarranted? Are the signs, enumerated as early signs, to be regarded as actual early signs of the disease as measured by the time of clinical recognition and diagnosis?

Dempster[3] in his small volume entitled "Medical Writing" quotes Graham Wallas who wrote of what he calls the intellectual stages of any creative written work, namely, preparation, incubation, illumination and verification of the final result. With the employment of longer periods of preparation and incubation many writers would be prevented from arriving at erroneous conclusions. However, those who present their subjects, not too dogmatically, and who have made all available attempts at verification of their conclusions may be pardoned if later investigation and research proves them to be incorrect. Had the periods of incubation and preparation of my paper been longer I would, perforce, have had to take into consideration a case which occurred soon after the publication of the article. A patient who was studied by serial roentgenograms developed a subperiosteal hemorrhage in the femur. Clinically, the diagnosis was confirmed by the usual signs and symptoms. At no time did the roentgenograms reveal any of the changes which I had described as occurring in the prehemorrhagic stages. To have this occur within several months after publication of the paper was, to say the least, disconcerting (Fig. 1).

Caffey[2] in 1941 stated that in human scurvy the deficiency of vitamin C is rarely complete or continuous but there is more frequently a series of fluctuating remissions and relapses that produce synchronous active and healing lesions in the bones. For this reason he believes the skeletal changes cannot be satisfactorily classified into progressive stages from early onset to complete healing. This might explain the roentgen findings in the case just quoted. Sufficient vitamin had been given to obscure the usual signs of scorbutic atrophy but not sufficient to prevent the formation of a subperiosteal hemorrhage.

In 1935 Kato[4] published an excellent critique of the roentgen signs of infantile scurvy and emphasized the fact that none of these signs is pathognomonic except the subperiosteal hemorrhages. It is, of course, well known that the increased density of the zone of temporary calcification is found in congenital syphilis, in healed rickets, in poisoning by lead and other heavy metals. Zones of lessened density appearing behind

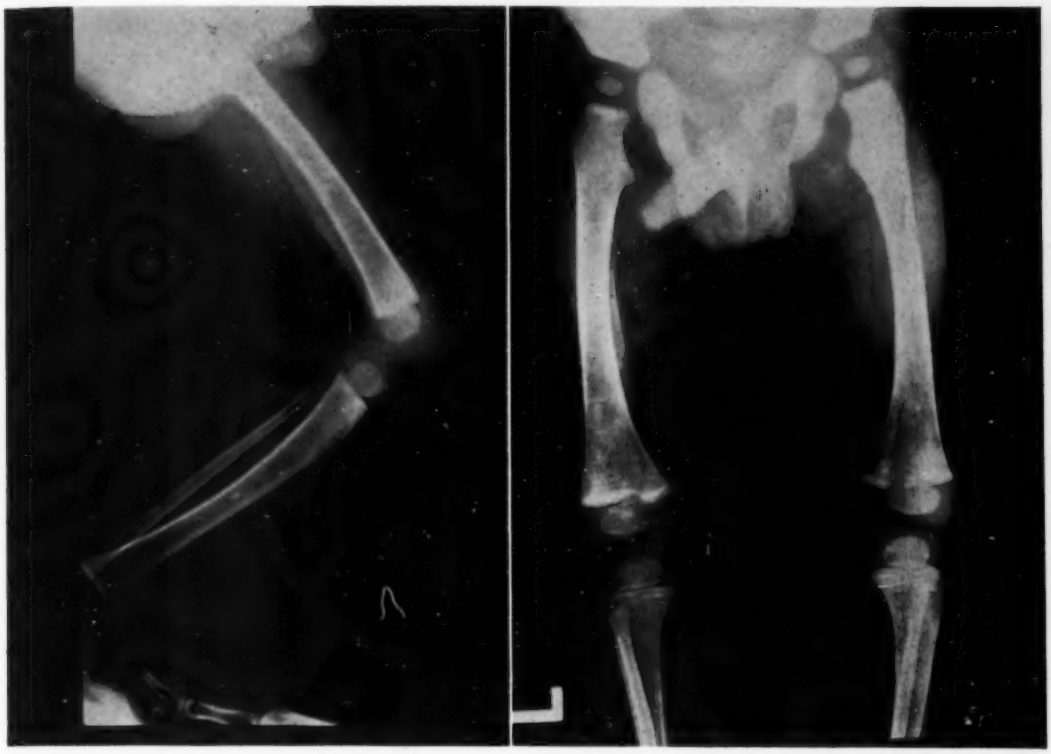


Fig. 1. Subperiosteal hemorrhage in the femur. No other roentgen signs of infantile scurvy are shown.

the zones of temporary calcification are found in congenital syphilis and in the bone changes of leukemia. The ring about the epiphyseal center can be found in cases of residual palsy following anterior poliomyelitis or bone atrophy due to other causes. Lateral spur formation can be found occasionally in rickets uncomplicated by scurvy, and epiphyseal separations occur in congenital syphilis. It cannot be too strongly emphasized that the roentgen appearance of the atrophy caused by scurvy is a composite one and that the diagnosis is based on the signs considered collectively. Other causes of bone atrophy must be eliminated by differential diagnostic methods such as the history and clinical laboratory examinations.

In 1935, Park and his associates[5] published in the Sir Thomas Barlow Birthday number of the *Archives of Diseases in Childhood* a most voluminous and exhaustive study of the early bone changes in infantile scurvy. The early roentgen signs were described and were detected in the lower ends of the diaphyses of the radius, ulna and tibia and in the upper end of the humerus. In the knee joint, the distal end of the femur only showed the lesions when the scorbutic process was well advanced. The upper end of the diaphysis of the tibia also showed changes but it was not as valuable a site for their demonstration as the distal ends of the ulna and radius. In the roentgenogram the changes were the slightest fuzziness of the cortex at the distal outer border of the diaphysis with the slightest rarefaction of the neighboring cancellous tissue. The cortex was so thin in some cases as to be altogether lacking. When the lesion was further developed, the defect became more definite. It then assumed the form of a cleft or crevice just behind the distal border of the diaphysis. In some cases this crevice was so slight that it almost escaped notice. In others it extended a short distance into the substance of the bone or half way across, or it had the appearance in

FIG. 2. Slight rarefaction and indentation at the distal border of the diaphyses of the radius and ulna illustrating the sign described by Park *et al.*, the so-called "corner sign."

some instances of having been torn away from the shaft of the bone itself. Sometimes instead of a cleft, the outer corner of the distal, lower border of the diaphysis showed a triangular area of rarefaction. In others, this corner appeared rounded and was thrust beyond the outer end of the distal extremity and was greatly rarefied. Park called this sign "bagging." Others in referring to it have termed it the "corner sign." The underlying pathological changes causing the findings in the roentgenograms are very completely described in the article by Park and his associates (Fig. 2).

In their conclusion they state that there are no early roentgen signs of scurvy. The slight roentgen changes described enable the diagnosis to be made by roentgen examination of the skeleton somewhat earlier than previously. The scorbutic deformity of the ribs is useful as a means of recognition of the disease when fully developed. The chief reliance, however, must still be on symptoms and, of these, pain and tenderness in the legs are the most important.

In their discussion of the early signs of scurvy, Park *et al.* stated that ground glass rarefaction of the shaft is not indicative of an early stage of the disease and emphasized the fact that it is not pathognomonic as it occurs in atrophy due to other causes than scurvy. The cortex does become thin and the bone does present a ground glass appearance but, they state, the bone intervening between the cortical shadows in the roentgenogram does not have a ground glass texture if it has reached an advanced stage of development. The ground glass quality is caused by an increased porosity of the cortex and the increased porosity is the result of absorption of the walls of the tunnels in the cortex.

This paper by Park and his associates necessitates a revision of the signs. The "corner sign" is one of the early if not the earliest roentgenographic sign. Shall the other signs described as occurring in the first stage be discarded as early signs? In the series reported in my paper of 1928, the ground glass appearance and thinning of the cortex and the other signs enumerated were found in 13 of the 56 cases in which a questionable clinical diagnosis had been made in 2; 5 had been diagnosed as scurvy; 4 were sent for roentgen examination with diagnoses other than scurvy, and in 2 cases no record could be found of the diagnosis made before roentgenological examination. This indicates that even if the ground glass appearance and thinning of the cortex are not early signs, they nevertheless are useful in making a diagnosis of scorbutic atrophy previous to the roentgen recognition of subperiosteal hemorrhages and even before the clinical diagnosis is possible. It may be wise, in view of Park's work, to make no attempt to divide the prehemorrhagic stage into two roentgenographic stages. However, in the analysis of the cases of the 1928 series, Pelkan's[6] contention was borne out that when the zone of rarefaction appears in the roentgenogram the disease is so far de-

veloped that clinical recognition is easy. If the "corner sign" is not always found, it may be due to the lack of sufficiently early examination.

The increased interest and the education of the laity in vitamin deficiency and more numerous Child Welfare and Health Clinics have tended to reduce the incidence of infantile scurvy. However, for numerous reasons a child may refuse his orange juice or the administration of vitamin C in other forms and the deficiency of the vitamin may be incomplete or not continuous. It may well be that the majority of patients suffering from infantile scurvy either now or in the future will conform to the type as stated by Caffey. Granted that there are or will be few cases which progress to subperiosteal hemorrhages by a continuous lack of vitamin, is it not useful to know the appearance and the progression of the lesions roentgenographically from the earliest detectable signs through the stage of subperiosteal hemorrhage to the healing stage? Is it not advantageous to know the signs of healing as it occurs before the hemorrhages appear? It should be the aim of the roentgenologist to assist in making the diagnosis before their appearance. Knowing and recognizing the progression in the cases of continuous lack of vitamin, it will be less difficult for the roentgenologist to recognize the signs of healing and remission in those cases in which the lack is not continuous.

REFERENCES

1. Bromer, R. S. Roentgen-ray diagnosis of infantile scurvy. Am. J. Roentgenol. & Rad. Therapy, 1928, *19*, 112–125.
2. Caffey, J. In: Diagnostic Roentgenology. Ross Golden, Editor. Thomas Nelson & Sons, New York, 1941. Chap. 15, p. 1044.
3. Dempster, J. H. Medical Writing. Bruce Publishing Co., St. Paul, 1937.
4. Kato, K. Critique of the roentgen signs of infantile scurvy, with report of 13 cases. *Radiology*, 1932, *18*, 1096–1110.
5. Park, E. A., Guild, H. G., Jackson, D., and Bond, M. Recognition of scurvy with especial reference to early x-ray changes. *Arch. Dis. Childhood*, 1935, *10*, 265–294.
6. Pelkan, K. F. The roentgenogram in early scurvy. *Am. J. Dis. Child.*, 1925, *30*, 174–188.

CALCIFICATION OF RENAL TUMORS*

By GEORGE AUSTEN, JR., M.D.
BOSTON, MASSACHUSETTS

THERE are many factors to be considered in determining the prognosis in cases of renal cancer, but experience has proved that no factor alone is of infallible aid. For this reason, any variation in the usual pattern of renal tumors should be studied to determine whether it has a significant relationship to the prognosis of kidney tumors in general. One of the occasional variations in the pattern of these neoplasms is the occurrence of calcium in the tumor tissue. Although the literature abounds in articles dealing with calcification of the kidney in tuberculosis and other conditions of so-called metastatic calcification, comparatively little attention has been directed to the calcification of renal tumors. When reviewing our cases in an effort to analyze factors of importance in prognosis, we noted an apparently unusual number of calcified deposits in the series. Since the majority of textbooks and monographs on urology make little reference to this condition, it seems worth while to report in brief the results of an analysis of these cases.

For those interested in the physical, pathological, and physiochemical aspects of calcification reference is made to the excellent studies of Virchow,[21] Wells,[23,24] Schmidt,[20] Barr,[5,6,7] and Albright.[2,3] In brief review, however, it is known that calcification occurs in the human body as either a physiologic or a pathologic process. The former is a normal process concerned with the deposition of calcium salts in the development and formation of bone. The latter is an abnormal process in which calcium salts are deposited or precipitated in tissues or organs which do not ordinarily contain such deposits.

Although advances are being made in the study of both physiologic and pathologic calcification, the exact physiochemical changes involved in the deposition of calcium are not yet clearly understood. Apparently the initial factor in pathological calcification is a loss of local cellular activity. This is followed by degenerative and retrogressive changes such as hyalinization, necrosis, and cyst formation. Thereafter, as Wells stated in 1911,[23] "The insoluble salts are laid down in a matrix especially prepared to receive them; in bone formation the homogeneous acellular matrix of the cartilage; in calcification some acellular necrotic tissue, or more especially, homogeneous elastic fibers or hyaline degenerated connective tissue, each of these latter bearing marked structural resemblance to the hyaline matrix of cartilage or osteoid tissue." But why calcium deposits should appear in one and not the other of two otherwise histologically similar tissues is still unsolved. Undoubtedly the amount of blood supply is important; with a free circulation there is no calcification; with too little circulation necrosis is followed by slow calcification or none at all. However, as believed by Wells and others, and as stated recently by Goldstein and Abeshouse,[13] "It is generally agreed that any dead or damaged tissue, infected or uninfected, so large or so situated that it cannot be absorbed, may become infiltrated with calcium salts. . . . The degree or extent of the calcification may be modified by general changes in calcium metabolism or in the amount of calcium in the blood or tissue fluids." Where calcification occurs in renal tumors, there is little or no evidence that the concentration of serum phosphatase or serum calcium and phosphorus plays any important rôle in this abnormal calcium deposition.

The appearance of calcium deposits in renal tumors is not mentioned in the early treatises on that subject by Albarran and Imbert[1] or by Garceau.[12] In 1901, Morris[19]

* From the Urological Clinic of the Peter Bent Brigham Hospital and the Laboratory for Surgical Research, Harvard Medical School, Boston, Massachusetts.

described a case of alveolar carcinoma of which the renal capsule cut as if calcified in parts, but he ascribed no prognostic sigficance to this phenomenon. Quoting Robert's observation he stated that "A fibrous tumor growing on the substance of the kidney may ossify and transform a large part of the organ into a bony mass." Although all authors describe the occurrence of cartilage, and occasionally bone, in the mixed embryonal tumors of the kidney, Watson and Cunningham,[22] Kelly and Burnam,[15] and Young[25] make no reference to calcification in other types of renal neoplasms. The attention of the urologist and roentgenologist was drawn to this interesting pathological change in the more common renal cancers by Arkin[4] in 1926. He reported the first case of calcification in a hypernephroma in which an accurate diagnosis was made by roentgenographic study and confirmed by operation. Since that time, other reports of this phenomenon have appeared with greater frequency in the literature. These have been recently summarized by Goldstein and Abeshouse.[13] However, in spite of the increasing frequency of these reports in the literature, the recent textbooks of urology fail to review in detail this feature of kidney tumors. In discussing papillary carcinoma with clear cells, Ewing[11] states: "The gross structure is divided into many small cysts containing clear or brownish or bloody or gelatinous material. Areas of necrosis and hemorrhage may be frequent, and these may fuse, yielding large cystic cavities. There may be considerable calcific deposits." Hinman[14] reproduces a roentgenogram showing calcium deposition in a tumor, and says: "Occasionally renal tumors become diffusely calcified and may give a characteristic X-ray picture." MacKenzie,[18] in discussing the various types of benign adenomas in Cabot's "Modern Urology," states that cystic changes may occur in these tumors and adds that "Calcareous changes are also relatively common." Under the subject of hypernephroma, Keyes and Ferguson[16] say: "The tumor usually remains quiescent from 45 to 60 years. It may then grow so slowly that a marked

Fig. 1. Roentgenogram of encapsulated hypernephroma with calcification in a female, aged sixty-two. Left nephrectomy.

desmoplastic reaction is set up in the kidney about it, and this process may go on to complete calcification in the capsule of the tumor. We have seen such a tumor, the capsule of which was so hard as to require the use of a skull saw for its division." Eisendrath and Rolnick[10] state: "One can see calcified areas in a hypernephroid tumor but so seldom does this occur that plain radiography in general may be said to be of little assistance in making a diagnosis." In the latest textbook of urology by Lowsley and Kirwin[17] no reference is made to this subject.

From April, 1913, to May, 1941, 131 tumors of the kidney were recorded in the files of the Peter Bent Brigham Hospital, 25 of which were not verified by pathological examination. In this group of 25 there were 3 which showed roentgenographic evidence of calcium shadows in the tumor. In each the symptoms were of at least two years' duration, a mass was palpable in the flank, and death occurred as a result of the disease four to twelve months after examination.

Fig. 2. Roentgenogram of large inoperable right hypernephroma in a male, aged fifty-two. Biopsy. Note diffuse calcification.

Although these cases are not included in the mortality figures, it is interesting to note that the calcium deposits demonstrated roentgenologically in this group are similar to those seen in the verified cases of renal tumor.

Of the 106 tumors verified by microscopic examination, 98 were malignant and 8 were benign. In the latter group were 6 adenomas of the renal parenchyma, 1 papilloma of the renal pelvis, and 1 leiomyoma of the renal pelvis. Only one of these, the leiomyoma, showed abnormal calcification. Of the 98 malignant neoplasms, 85 were carcinomas of the renal parenchyma, 8 were tumors of the renal pelvis, and 5 were miscellaneous tumors, including 2 embryonal or Wilms' tumors, 1 fibrosarcoma, 1 leiomyoliposarcoma and 1 lipofibrosarcoma.

Calcium deposits in the tumor tissue were demonstrated by roentgenologic and microscopic examination in 16 of the 98 malignant cases, a percentage of 16.3. Of these 16 cases, 14 were carcinomas of the renal parenchyma, 1 was a papillary carcinoma of the renal pelvis, and 1 was a leiomyoliposarcoma of the renal capsule. There were 12 males and 4 females in the group, with an average age of 53.5 years, the youngest being twenty-seven and the oldest sixty-seven years. The right kidney was the site of calcification in 5 instances, the left in 11 instances. Since many malignant tumors of the kidney cause no symptoms in the early stages of their growth, it is difficult to determine even approximately how long they have existed, although it is probable that they have been present for some time before manifesting themselves. In our group of cases with calcified tumors, the average duration of symptoms varied between five and eight months, the shortest interval between the onset of symptoms and operation being two weeks, the longest two years. In contrast, the average duration of symptoms for cases with non-calcified malignant tumors varied between ten and fourteen months.

Studies before operation revealed no evidence of distant metastasis in any of these patients. The tumor mass, palpable in 12 of the 16, was easily movable in the majority. Except for 1, who showed the systemic effects of necrosis and infection in the tumor, all were considered to be good operative risks. Nephrectomy was performed in 14 cases, while 2 were subjected only to biopsy because of the extensive local invasion of the tumor found at exploration. No deaths occurred during the immediate postoperative period.

The shadows of calcification in renal tumors, as seen in the roentgenograms, assumed various patterns and were not in themselves distinctive. In the majority of cases, however, the involved kidney was enlarged or irregular. The calcified material could be demonstrated to lie in the area of the suspected mass and could be localized even more after the injection of a radiopaque iodide solution. Some shadows showed a scattering of irregular, mottled deposits throughout the entire tumor, while others showed only several small spiculated deposits in either the central or peripheral portions. Sometimes the calcified material

was arranged in radial or circular strands, occasionally in whorls. One case had strands of calcium deposited in a laminated pattern and confined to a quadrant of the apparent capsule of the tumor. When deposited in clusters, the shadows were of quite irregular consistency. In two instances the calcium deposits closely resembled those seen in renal tuberculosis and were diagnosed as such when roentgenograms showed old tuberculous lesions in the lungs. However, further study of the retrograde pyelograms showed no cavitation or ulceration of the calyces, and the clusters of calcium could be seen extending into the tumor area. Similarly, the calcified areas in the papillary carcinoma of the pelvis were at first mistaken for pelvic calculi, but on closer examination after pyelography, they appeared more irregular in shape and consistency than the usual calculi and were apparently scattered in strands throughout a mass which almost filled the pelvis. Braasch and Griffin[8] have pointed out that one must distinguish carefully between the calcified shadows in renal tumors and those caused by lithiasis and tuberculosis. They state that "the absence of any clinical, cystoscopic, or urographic data suggestive of either lithiasis or tuberculosis usually would exclude these conditions."

A rigid pathological classification of carcinomas of the kidney parenchyma is impossible because of the varied cellular picture found in different portions of the same tumor. This fact would seem to substantiate the theory that the majority of these tumors are of renal origin. We have therefore attempted to group our 14 calcified cases according to the predominant type of structure present. Thus, there were 9 carcinomas of the so-called "hypernephroma" type, 2 papillary adenocarcinomas, 1 tubular or alveolar carcinoma, and 2 small cell carcinomas. Pathological sections of these tumors, as well as of those of the pelvis and capsule, showed multiple areas of hemorrhage, necrosis, and cystic degeneration. The degenerative changes varied in degree, some being grossly visible on section, while others were microscopic in size. There were

FIG. 3. Roentgenogram of rapidly growing small cell carcinoma of right kidney in a male, aged twenty-seven. Right nephrectomy. Note diffuse calcification in tumor at upper pole.

both recent and old areas of hemorrhage. Many sections showed replacement of these areas by fibrous tissue proliferation, collagen deposition, and hyalinization. Calcium was always deposited in or about these areas, in some instances apparently precipitated directly in the center of a mass of necrotic cells, but more often deposited in the interstices of the hyalinized fibrous tissue. Deposits were also found surrounding small vessels adjacent to regions of necrosis and hemorrhage. These vessels were supported by an extremely delicate stroma, in which were cords of partially degenerated tumor cells, and they frequently showed a marked proliferation of their endothelial lining and almost complete obliteration of their lumina. In one case cholesterol crystals were found in a small area of necrosis, while in another there was an abortive attempt at cartilage formation. In a third instance true bone formation was seen about the periphery of a large mass of necrotic material. Except in 2 cases where a

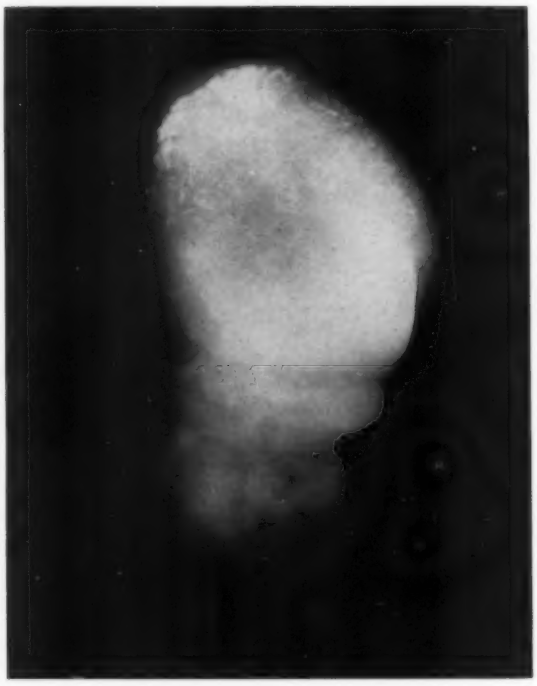


Fig. 4. Roentgenogram of specimen of small cell carcinoma with calcification shown in Figure 3.

coexisting acute and chronic pyelonephritis existed, there was little or no inflammatory reaction in the tumor tissue adjacent to regions of necrosis and calcification.

Follow-up data were available on 13 of the 16 cases. Of this group, 2 patients, 1 with hypernephroma and 1 with a papillary carcinoma of the pelvis, are living and well one and one-half and five years respectively after nephrectomy. Two patients, both of whom had clear cell carcinomas of the hypernephroma type, are alive one and two years after nephrectomy, but both have multiple metastases. Seven patients died of metastases within four to forty-eight months after operation. Five of these were subjected to nephrectomy, while 2 had merely an exploratory operation and biopsy. Two patients died of the complications of cardiovascular disease two and two and one-half years after nephrectomy but in neither instance was there any evidence of recurrent or metastatic tumor. Of the 3 patients whose status is at present unknown (all of whom had tumors of the hypernephroma type) 1 was alive and well approximately one year after nephrectomy, while 2 were alive but had metastases within one and one-half years after operation. Thus, if we include only the 13 cases of which we have follow-up data, the survival rate is 15.3 per cent. If we include the remaining 3 cases and assume that 1 is alive and 2 are dead, the survival rate rises to 18.7 per cent. In contrast, the survival rate for the 82 cases of tumors without calcification averages between 28 and 33 per cent.

COMMENT

The occurrence of calcification in 16.3 per cent of our malignant renal neoplasms would seem somewhat unusual were it not for the fact that others (Braasch and Griffin,[8] and Cahill and Melicow[9]) also report an incidence almost as high. Although calcification does occur in tumors of other organs of the body, notably in some tumors of the brain and in benign uterine leiomyomata, the calcified deposits in these instances are generally considered to be indicative of the slow growth and relatively benign character of the lesions. Benign tumors of the kidney, however, are comparatively rare, and in our series only 1 (12.5 per cent) of 8 benign lesions showed calcification. Comparing this figure with that of the malignant tumors, it is evident

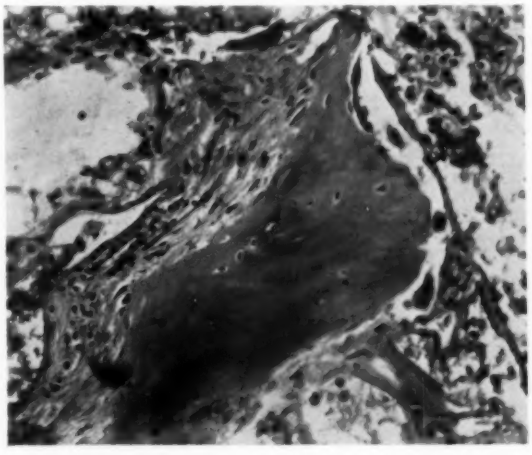


Fig. 5. Photomicrograph of hypernephroma removed from a male, aged fifty-six. This is the only case in which true bone formation was seen. Eosin and methylene blue stain. ×300.

that the appearance of calcification in the roentgenograms is no indication of the benign or malignant character of the tumor.

As stated previously, experimental and clinical observation has shown that the pathological deposition of lime salts is dependent upon loss of cellular activity, hemorrhage, necrosis, and hyalinization. Since malignant tumors of the kidney are particularly prone to these degenerative changes, they might be expected to show pathological calcification rather frequently. Although the rate of calcification is extremely variable and not proportionate to the degree of hemorrhage, it is of interest to note that in the cases having calcified tumors the duration of symptoms from the onset to the time of treatment was definitely less than in those which had non-calcified tumors. On the other hand, the *amount* of calcium deposited in a given area is entirely independent of the extent of degeneration and appears to be governed by some factor or factors as yet undetermined. This feature of pathological calcification is well exemplified in the present series where as much or more calcium was found in tumors with minimal areas of necrosis as in those with larger areas. Moreover, there seemed to be no direct relation between the degree of hemorrhage or necrosis and the grade of malignancy as judged by the usual gross and microscopic criteria. Many of the non-calcified neoplasms which were considered comparatively benign by microscopic examination showed equally as much hemorrhage and necrosis as others which were considered extremely malignant. Likewise, the size of the tumor appeared to have no direct bearing upon the extent of degeneration, the amount of calcification, or the degree of cellular activity, although in general the larger neoplasms showed more extensive necrosis than the smaller ones.

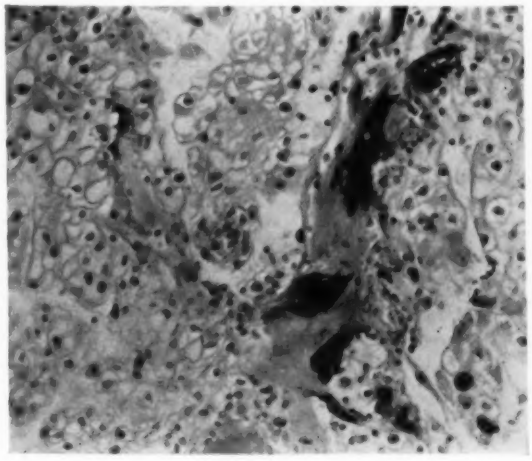


Fig. 6. Photomicrograph of hypernephroma removed from a male, aged sixty-two. Calcium deposited in strands.

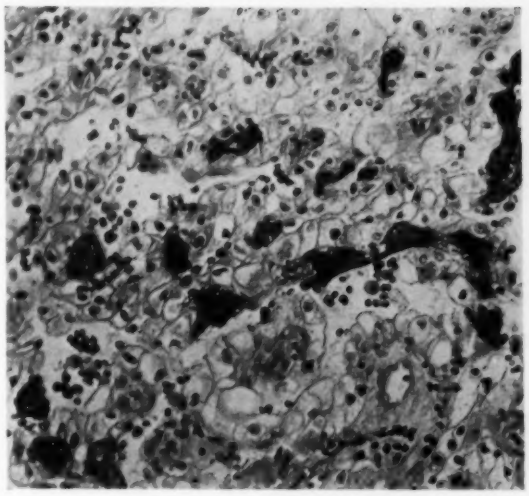


Fig. 7. Photomicrograph. Same case as Figure 6, showing more scattered deposits of calcium than in the previous figure.

While no accurate deductions as to the specific cause and significance of the calcification occurring in malignant renal tumors can be derived from these observations, the occurrence of this phenomenon may be of some prognostic importance. Braasch and Griffin[8] noted roentgenographic evidence of calcification in 7 cases and stated that 4 of these were alive at the end of five years. They feel that calcium deposition in renal tumors is a favorable sign. Goldstein and Abeshouse[13] hold a similar opinion. Cahill and Melicow,[9] on the other hand, consider the prognosis of tumors with calcification to be less encouraging than those without calcification. They reported 12 verified and 2 unverified cases of renal tumors with calcification, only 1 of whom

was alive without demonstrable metastases two years after operation. Our figures tend to substantiate their experience. In our series the survival rate of those with calcification is 15.3 per cent, while of those without calcification it is approximately 30 per cent. However, because of the statistical standard of error inherent in figures based on such a small number of cases, it must be said that this analysis precluded the possibility of drawing positive conclusions until further observations on this subject are reported by others.

SUMMARY

1. A review of 98 verified malignant tumors of the kidney has been made. Of this group, 16 tumors showed calcium deposits by both roentgenographic and pathologic examination.

2. The significance of this phenomenon has been discussed.

3. While the survival rate of those cases without calcification is approximately 30 per cent, for those with calcification it is 15.3 per cent.

4. Although no positive conclusions as to the prognostic importance of this condition can be derived from the study of such a small series, it appears that the prognosis of those cases with calcification is less favorable than of those without calcification.

REFERENCES

1. Albarran, J., and Imbert, L. Les tumeurs du rein. Masson et Cie, Paris, 1905, pp. 501–511.
2. Albright, F., Baird, P. C., Cope, O., and Bloomberg, E. Studies on physiology of parathyroid glands; renal complications of hyperparathyroidism. *Am. J. M. Sc.*, 1934, *187*, 49–65.
3. Albright, F., and Bloomberg, E. Hyperparathyroidism and renal disease, with note as to formation of calcium casts in this disease. *J. Urol.*, 1935, *34*, 1–7.
4. Arkin, A. Calcified hypernephroma of the kidney. *Surg., Gynec. & Obst.*, 1926, *43*, 155–168.
5. Barr, D. P., Bulger, H. A., and Dixon, H. H. Hyperparathyroidism. *J. Am. M. Ass.*, 1929, *92*, 951–952.
6. Barr, D. P., and Bulger, H. A. Clinical syndrome of hyperparathyroidism. *Am. J. M. Sc.*, 1930, *179*, 449–476.
7. Barr, D. P., and Charles, C. M. Relation of diseases of bone to arterial calcification and urolithiasis. *Libman Anniv. Vols.*, 1932, *1*, 155–179.
8. Braasch, W. F., and Griffin, M. Prognosis in renal carcinoma and clinical and pathologic data affecting it. *J. Am. M. Ass.*, 1936, *106*, 1343–1346.
9. Cahill, G. F., and Melicow, M. M. Calcification of renal tumors and its relation to prognosis. *J. Urol.*, 1938, *39*, 276–286.
10. Eisendrath, D., and Rolnick, H. C. Urology. Fourth edition. J. B. Lippincott Co., Philadelphia, 1938.
11. Ewing, James. Neoplastic Diseases. Third edition. W. B. Saunders Co., Philadelphia, 1934.
12. Garceau, Edgar. Renal, Ureteral, Perirenal and Adrenal Tumors and Actinomycosis and Echinococcus of the Kidney. D. Appleton and Co., New York, 1909.
13. Goldstein, A. E., and Abeshouse, B. S. Calcification and ossification of kidney; review of literature and report of cases. *Radiology*, 1938, *30*, 544–578; 667–685.
14. Hinman, F. The Principles and Practice of Urology. W. B. Saunders Co., Philadelphia, 1936, p. 1032.
15. Kelly, H. A., and Burnam, C. F. Diseases of the Kidney, Ureter and Bladder. Second edition. D. Appleton and Co., New York, 1922.
16. Keyes, E. L., and Ferguson, R. S. Urology. Sixth edition. D. Appleton-Century Co., New York, 1936, p. 361.
17. Lowsley, O. S., and Kirwin, T. J. Clinical Urology. Williams and Wilkins Co., Baltimore, 1940.
18. MacKenzie, D. W. In: Modern Urology. Hugh Cabot. Third edition. Lea and Febiger, Philadelphia, 1936, p. 692.
19. Morris, Henry. Surgical Diseases of Kidney and Ureter. Cassell and Co., London, 1901, pp. 557–626.
20. Schmidt, M. B. Ueber die Verkalkung der Nierenepithelien bei Sublimatvergiftung und bei Dysenterre. *Centralbl. f. allg. Path. u. path. Anat.*, 1920, *30*, 497–500.
21. Virchow, R. L. Kalk-Metastasen. *Virchow's Arch. f. Path.*, 1855, *8*, 103.
22. Watson, F. S., and Cunningham, J. H. Diseases and Surgery of Genito-Urinary Tract. Lea and Febiger, Philadelphia, 1908, p. 239.
23. Wells, H. G. Calcification and Ossification. The Harvey Lectures. 1910–1911, pp. 102–146.
24. Wells, H. G. Chemical Pathology. Fifth edition. W. B. Saunders Co., Philadelphia, 1925, pp. 486–504.
25. Young, H. H. Practice of Urology. Third edition. W. B. Saunders Co., Philadelphia, 1926, p. 520.

Vol. 49, No. 5

ROENTGENOLOGIC EXAMINATION OF THE PHARYNX

By SIEGFRIED W. WESTING, M.D.
*Roentgenologist, Brooklyn Cancer Institute**
BROOKLYN, NEW YORK

IN THE majority of cases a complete examination of the three portions of the pharynx, namely, the nasopharynx, the oropharynx, and the laryngo- or hypopharynx, can be made by the rhinolaryngologist without the help of roentgen procedures. Yet there are numerous instances where a roentgenologic examination may be of material assistance. When the nasopharynx is the seat of a malignant new growth the roentgenologist may have to determine whether or not extension into the adjacent bones (the base of the skull) is present. The oropharynx, although easily accessible to inspection and palpation, may be subjected to roentgen examination to great advantage, particularly in order to visualize the valleculae, the two important recesses in front of the base of the epiglottis. Regarding the hypopharynx the roentgen examination is able to add a good deal of confirmatory and contributory information to the rhinolaryngologic study. Here again the leading rôle is played by two recesses: the piriform sinuses which hang down from the two lateral aspects of the anterior surface of the hypopharynx and are adjacent to the sides of the larynx. If a hypopharyngeal lesion is so large that the rhinolaryngological instruments cannot pass it, the only means to determine its lower end is the roentgen study (see Cases III and V). This study at the same time reveals the condition of the neighboring organs, for instance, the retropharyngeal tissues. Thus information is obtained roentgenologically which cannot be acquired otherwise.

The reader who wishes to familiarize himself with the roentgen study of the pharynx is referred to a number of recent publications.[5,6,8] Here he finds instructions about the roentgenoscopy, roentgenography and planigraphy (body section roentgenography) of the structure and function of the pharynx in times of health and disease. In spite of the wealth of information thus available, the pharynx does not universally receive from the roentgenologist the amount of attention which appears warranted.

Such neglect would be of less consequence if the contacts of the roentgenologist with the pharynx were confined to cases referred to him by the rhinolaryngologist. Actually these contacts are much more numerous. Whenever the roentgenologist is performing an opaque meal examination of the alimentary tract, he has an opportunity to examine the lower half of the pharynx and it is this opportunity that is neglected quite frequently as illustrated by the fact that most reports about a so-called gastrointestinal series and most books on roentgen examination of the alimentary tract[2,3,7] start with a description of the esophagus instead of the lower pharynx which is really the first segment passed by the meal after it leaves the mouth. Two reasons seem to explain this subordinate position of the pharynx.

First, the roentgenologist who sets out to examine the alimentary tract may take it for granted that in the absence of the suggestive symptom of difficulty in swallowing, the pharynx can be ruled out as the seat of affection. That this assumption is fallacious is exemplified by our Case III, where advanced pathological changes are present without characteristic symptoms. It is obvious that under such circumstances the roentgenologist may create a situation quite embarrassing to himself if he should happen to overlook and fail to report important pathological changes which with correct technique and careful interpretation could have been revealed.

The second reason for the lack of attention directed toward the pharynx is the

* Department of Hospitals, City of New York.

FIG. 1. Posteroanterior view of a specimen of a normal tongue, larynx, lower half of pharynx and proximal end of trachea and of esophagus after fixation in formalin. Slightly stained with barium water mixture. Note the valleculae (somewhat flattened out as compared to condition during life); piriform sinuses, just inside of the lime containing laminae of the thyroid cartilage; air space of larynx and upper trachea, vocal cords in paralysis position, and mucosal pattern of upper esophagus. Visualization of this pattern is very rare, as during life food is evacuated from this segment exceedingly rapidly.

FIG. 2. Posteroanterior view of the same specimen more completely filled. This picture illustrates the roentgenoscopic appearance of the barium stream in this area. During life in many instances the upper portion of the shadow solidly fills the space between the piriform sinuses. In other instances, as in our illustration, there is a defect in the middle part due to the backward bulge of the larynx. As the larynx rises during the act of swallowing the square shaped, non-filled area beneath the valleculae, visible in this illustration, does not exist during deglutition. The constriction of the uppermost centimeter of the esophagus is not evident in the specimen.

FIG. 3. Lateral view of the same specimen, almost completely filled. The valleculae are superimposed on one another. The piriform sinuses are superimposed on one another and very often on the main portion of the hypopharynx so that they are not visible as separate structures. However, turn to Figure 6 where the superimposed piriform sinuses are seen just in front of the main portion of the hypopharynx. It should be remembered that during rest the anterior esophageal wall is adjacent to the posterior wall. This fact accounts for the thread-like appearance of the non-expanded normal esophagus in the lateral view.

FIG. 4. Oblique view of the same specimen.

short duration of the filling of the normal pharynx. It takes the food no longer than one-eighth of a second to travel from the back of the tongue through the oro- and hypopharynx and cervical portion of the esophagus to the level of the clavicles.[1] From there on the descent is much slower. Changing the patient's position from upright to horizontal slows up the speed below the clavicles but has no effect above the clavicles. Even turning the subject on his head fails to retard the food in the uppermost segment of the alimentary tract.[4,9] Therefore on almost all roentgenograms, provided they reach up high enough in the neck region, this upper segment is found either empty or filled by small streaks of barium. This being the case, the rôle of roentgenoscopy becomes more important. The roentgenoscopist is likewise handicapped by the exceedingly transitory character of the filling of the pharynx and cervical esophagus. It is not possible to note accurately a visual impression in one-eighth of a second, if immediately afterwards the entire attention is to be concentrated on the important phenomena noticeable farther down as the first bolus

passes through the esophagus and cardia into the stomach.

In order to make an adequate examination of the pharynx and cervical esophagus, one ought to make it a rule to return to this region after he has finished the study of the stomach as it gradually expands under the influence of increasing amounts of opaque mixture. It is really not before then that the roentgenologist is free to study the pharynx and cervical esophagus leisurely and without the fear that he may obscure important stomach findings by administering the number of swallows necessary for the study of the upper pole of the alimentary tract. In detail, the roentgenoscopist proceeds in the following manner. After the shutter has been adjusted to oblong shape and fitted exactly over the area of the lower pharynx and cervical esophagus, the patient is asked to fill his mouth with contrast meal. His head is turned straight forward. The chin is raised half way. Less elevation of the chin would let the chin cover the pharynx, more elevation would project the base of the skull into the field of examination. When the examiner has brought his eyes to the level of the pharynx the patient is ordered to swallow.

Fig. 5. Case 1. Posteroanterior view. Constricting carcinoma of the esophagus just above clavicles proved by histopathological study of biopsy specimen. The valleculae and piriform sinuses are clearly visible; they are structurally normal, proved by laryngoscopy and esophagoscopy. They are hypotonic and retain the food unduly long. Therefore a good opportunity to procure the picture of a structurally normal pharynx is afforded.

Fig. 6. Lateral view of the same case. Good demonstration of the air filled oro- and hypopharynx with barium in the bases of valleculae and piriform sinuses. One side is superimposed upon the other. The trace of barium in the collapsed hypopharynx behind the barium filled bases of the piriform sinuses records the relation of these structures. A little farther down the esophagus is dilated due to the constricting carcinoma just above the clavicles.

In normal cases the posteroanterior projection of the barium stream can be described as follows: In the beginning its width is determined by the distance of the lateral walls of the piriform sinuses. Right below this segment the esophagus starts.

FIG. 7. Case II. Oblique view. Valleculae and piriform sinuses stand out distinctly. Extensive malignant neoplasm within lower half of esophagus leading to partial obstruction and moderate widening of the esophagus above the obstruction. The diagnosis is based on the roentgenological and clinical evidence. No esophagoscopy could be done. Since I have not found an oblique view of the barium filled pharynx in the American literature, I deemed it advisable to include this case in spite of lack of laryngoscopic and histological proof.

The lumen of its first centimeter is concentrically narrowed to about three-fourths the width of the balance of the esophagus; from then on down the ordinary width of the esophagus is noted. The wide portion of the barium stream may be thinned out or absent in and next to the midline due to the backward bulge of the larynx. Figure 2 conveys a fairly good idea of the barium as seen during the act of swallowing. The chief characteristic of this view is the completely symmetrical appearance of the barium stream. This feature renders the posteroanterior projection especially valuable because of the possibility of comparing one side with the other. Even slight asymmetries may be of diagnostic significance. As soon as the bulk of the barium has left the pharynx, the region is scrutinized for residues. These residues in normal cases are small and of short duration. They are located in the valleculae and piriform sinuses.

Due to the small amount of barium re-

FIG. 8. Case III. Posteroanterior view. Filling of right vallecula and right piriform sinus very deficient and very irregularly outlined. Conclusion—advanced malignant new growth of right half of base of oropharynx and of right half of hypopharynx. Six days later, on October 5, 1939, laryngoscopy revealed the following: In the glosso-epiglottic fold there is a red friable mass which has a granular appearance. Biopsy was done which proved on histopathological examination to be squamous cell carcinoma. This case had been transferred to the Brooklyn Cancer Institute from another hospital on September 21, 1939, on account of a nontender swelling, size of a tangerine, posterior to the right sternocleidomastoid muscle. Biopsy of the mass had shown metastatic squamous cell carcinoma. Primary carcinoma was not known at time of transfer. The patient did not have any difficulty in swallowing. This case proves that the roentgen examination may precede the laryngoscopy and often is able to anticipate the laryngoscopic findings; sometimes it even can amplify the laryngoscopic findings inasmuch as it shows how far down a lesion extends. In our case the affection of the right piriform sinus so clearly revealed by the roentgen examination is not mentioned in the laryngoscopic report.

tained, roentgenograms of the pharynx, as a rule, are quite unimpressive. Therefore in preparing a set of normal roentgenograms for reference purposes, I found it practical to make use of the fact that in case of stricture lower down in the esophagus the amount and duration of these residues are greatly increased and the resulting appearances are much more demonstrative. We are dealing with "exaggerated normals," just as in excretion urography a compression band over the sacral region prevents the contrast fluid from draining too rapidly out of the renal calyces and pelves and thus produces "exaggerated normals." If one keeps in mind that the actual normals are of smaller size and shorter duration, the "exaggerated normals" may very well serve as paradigms of the actual normals. Although these pictures are quite characteristic, it may happen that the bizarre and torn appearance of the barium column in the upper segment of the alimentary tract confuses the less initiated interpreter and prompts him to suspect pathological filling defects. Experience proves that in cases similar to those illustrated by Figures 5, 6 and 7 a lesion in the hypopharynx and cervical esophagus has been assumed erroneously in addition to the true lesion farther down.

FIG. 9. Case IV. Posteroanterior view of a very advanced lesion. Laryngoscopically friable mass in right piriform sinus. Histopathologically squamous cell carcinoma.

FIG. 10. Case V. Posteroanterior view. Filling defects of both piriform sinuses. The calcification in the laminae of the thyroid cartilage should not be mistaken for barium in the piriform sinuses. Lateral view of the neck demonstrated tumor formation in the arytenoid region. The conclusion drawn from the roentgen examination was: large tumor in arytenoid region and piriform sinuses. Laryngoscopically—large mass in arytenoid region which obscures the posterior extremity of the vocal cords. Histopathological examination of biopsy specimen discloses squamous cell carcinoma. Again the two examinations supplement one another most satisfactorily. Roentgenologic examination determines the downward extent of the lesion better than the laryngoscopy. The fact that the lesion affects both piriform sinuses symmetrically renders the interpretation more difficult. Carcinoma frequently affects larynx and hypopharynx simultaneously. Keeping the possibility of such an association in mind, the roentgenologist should always feel prompted to scrutinize both organs even when the examination of one only is requested.

After roentgenoscopy in the posteroanterior projection has been completed, the patient is turned and the lateral and

oblique views are studied at rest and during phonation and swallowing, the latter without and with opaque mixture. The approximate appearance of the barium column in these views is illustrated by Figures 3 and 4.

Finally, according to the roentgenoscopic findings, the number and kind of roentgenographic views are decided upon. Ordinarily the posteroanterior and the lateral views are indispensable. Since larynx and hypopharynx are frequently involved jointly in the same pathological process, both organs have to be considered by the roentgenologist, even when the examination of one only is requested (see Case v).

SUMMARY

1. The place of roentgenology in the examination of the pharynx is stated briefly.

2. Attention is called to the fact that during each opaque meal study of the alimentary tract the roentgenologist has an opportunity to examine the lower half of the pharynx; an opportunity which is often neglected for reasons presented.

3. For the lower half of the pharynx and the cervical esophagus a roentgenoscopic technique is outlined which obviates the difficulties ordinarily arising during the opaque meal study of the alimentary tract.

4. Roentgenograms of the normal pharynx are described and reproduced in posteroanterior, lateral, and oblique projections. These roentgenograms were obtained from an autopsy specimen and from patients who, because of remote affection, are better suited to furnish us with pictures of the structurally normal pharynx than healthy subjects.

5. Cases of cancer are described—one very advanced case, one with definite, but less conspicuous findings, and one with absence of the customary characteristic history of dysphagia. As cancer frequently affects larynx and hypopharynx simultaneously, the roentgenologist should scrutinize both organs, even when the examination of one only is requested.

REFERENCES

1. BARCLAY, A. E. Practical importance of mechanics in digestion. AM. J. ROENTGENOL. & RAD. THERAPY, 1938, *40*, 325–334.
2. BUCKSTEIN, J. Clinical Roentgenology of the Alimentary Tract. W. B. Saunders Company, Philadelphia, 1940.
3. CARMAN, R. D. The Roentgen Diagnosis of Diseases of the Alimentary Canal. W. B. Saunders, Philadelphia, 1920.
4. PALUGYAY, J. Untersuchungen über den Schluckakt bei Kopfstand. *Klin. Wchnschr.*, 1923, *2*, 1720.
5. PENDERGRASS, E. P., and YOUNG, B. R. Roentgen diagnosis of neoplasms of air and food passages, with particular reference to the larynx. *Radiology*, 1941, *36*, 197–211.
6. PFAHLER, G. E. Roentgen diagnosis and treatment of carcinoma of larynx and pharynx. *Radiology*, 1939, *33*, 42–53.
7. ROSENTHAL, E. Diseases of the Digestive System. C. V. Mosby Company, St. Louis, 1940.
8. YOUNG, B. R. The Soft Tissues of the Air and Food Passages of the Neck. In: Diagnostic Roentgenology. Ross Golden, Editor. Thomas Nelson & Sons, New York, 1941.
9. THOMAS, A. R. Note on the mechanism of deglutition. *Brit. J. Radiol.*, 1942, *15*, 209–210.

Vol. 49, No. 5

POST-TRAUMATIC NECROSIS OF BONE*

By RAYMOND W. LEWIS, M.D.
Roentgenologist, Hospital for Special Surgery
NEW YORK, NEW YORK

IN RECENT years the increasing frequency of writings and discussions of aseptic bone necrosis is indicative of the importance of the subject, and of the ever widening interest in it. In this country the work and contributions of Phemister are outstanding in this field. A recent article of his, appearing in a surgical publication, is particularly comprehensive and instructive.[1] With the purpose of bringing to the attention of roentgenologists this highly significant work, and perhaps adding a few examples of the condition and discussing them from the roentgenological point of view, this paper was prepared. Omitted from the present discussion are the familiar types of aseptic necrosis occurring in growing centers of bone—the femoral head, tibial tubercle, tarsal scaphoid, metatarsal heads, vertebral bodies—known under the names of the various early writers on these conditions. Also omitted are the widely recognized lunate osteomalacia and osteochondritis dissecans, both of which probably should be classified in the post-traumatic bone necrosis group.

In the article referred to, Phemister writes in detail of the pathological processes following aseptic interruption of circulation in bone. From the surrounding living bone and joint structures there is fibrous invasion, and metaplasia and replacement of the dead bone by new bone. Phemister refers to this process as "creeping substitution" or "creeping replacement." The fibrous invasion and the metaplasia often go hand in hand; but in some cases the fibrous invasion may be far in advance of the zone of transformation, leaving a thick zone of dead bone filled with fibrous marrow. There is considerable variation in the rate of progress of this transformation, it being influenced by such factors as age, size and location of the necrotic area, function, trauma and non-union of fractures which may be present. Recent work by Phemister and coworkers showed that the reparative impulse may not last as long as dead bone persists, but that in the case of adults large necrotic areas may be incompletely removed. He also calls attention to the fact that, especially in adults, interruption of circulation in the bone of an epiphysis causes serious interference with the nutrition of the articular cartilage. He states that function hastens to some extent the rate and the extent of the repair, but he cautions that function should be limited well within the strength of the necrotic bone and of the newly forming bone during the major part of the period of creeping substitution. Otherwise fractures and more or less collapse of the articular portions may occur, with damage to the articular cartilage. If circulation of the cartilage is not restored, and it dies and becomes eroded, a chronic deforming arthritis is usually established.

Phemister gives an excellent description of the roentgen manifestations of the various stages of the process he has described. "There are no demonstrable changes in the early stages of aseptic necrosis. In case the cause of necrosis is a fracture followed by non-union resulting in marked disuse, there is enough atrophy of the adjacent living bone in one or two months to cause it to cast in roentgenograms a shadow fainter than that cast by the dead bone, which retains its original density. Fibrous tissue invasion of bone causes no change in density, but creeping substitution by new bone alters density. If it takes place in the presence of a considerable degree of

[1] Phemister, D. B. Changes in bones and joints resulting from interruption of circulation. *Arch. Surg.*, 1940, *41*, 436–472.

* Presented at the Eastern Conference of Radiologists, New York, N. Y., Jan. 23–24, 1942.

FIG. 1. Case 1. M.H., female, aged fifty-seven. Fell in January, 1937, sustaining a fracture of the femoral neck. The fracture was nailed, and roentgenograms over a period of four years show that union was obtained, but that there was a steadily progressing aseptic necrosis. *A* shows the original fracture. *B* shows the appearance about a year later. The proximal fragment is of greater density than the adjacent bones, and there are small areas of rarefaction indicating very limited creeping substitution. *C* shows the appearance about two years after the fracture. Union has taken place, but the reparative processes have been very incomplete, leaving the major portions of the devitalized head. *D*, taken a little more than four years after the fracture, shows crushing of the head, and fragmentation; and the completely dead upper quadrant of the femoral head has separated, and lies as a large loose body simulating osteochondritis dissecans.

disuse, as in a necrotic femoral head in a case of ununited fracture of the neck of the femur, the new bone is less dense than the old and casts a fainter shadow. In some of these cases central portions of the head may be replaced by fatty bone marrow, which gives the roentgen appearance of a cavity. If, however, there is little or no disuse, the new bone is laid down in greater amounts, and the density approximates the normal But the shadows of the trabeculae are usually irregular, which may suggest the previous existence of a necrotic area. Flattening of the articular surface and fracture lines within or at the limits of the dense bone are important signs. Compression of trabeculae, especially in necrosing lesions in children, may give rise to some degree of increased density." He continues further: "The calcified and ossified line of demarcation which may develop about a stationary necrotic area in the cancellous bone or the medullary cavity of the shaft casts a definite shadow of increased density in roentgenograms. There may also be sufficient calcification within to cause the entire necrotic area to cast a more or less blotchy shadow of increased density."

FIG. 2. Case II. J.L., female, aged twenty-six. Twenty-eight months ago she was in an automobile accident, sustaining multiple serious injuries, among others an intertrochanteric fracture of the femur. She was treated elsewhere, the femoral fracture was wired eight days after occurrence, and good union obtained. She was kept from weight-bearing only eight and a half weeks. A review of the roentgenograms taken elsewhere showed no evidence of circulatory disturbance until seven months after injury. From then on until we saw her, the aseptic necrosis was progressive. This was apparently not recognized; and it seems probable that her sutures were regarded as the source of her discomfort, for the accessible portions of these were removed shortly before we saw her. This roentgenogram shows her condition two years and four months after her accident. The femoral head and proximal neck are obviously dead. Central and scattered peripheral rarefactions represent incomplete creeping substitution. The head shows partial collapse. *Comment:* Had the circulatory disturbance been recognized, and function limited, it is theoretically possible that restoration might have been more complete, the crushing of the head prevented, and the now inevitable severe secondary osteoarthritis avoided.

FIG. 3. Case III. D.R., female, aged thirty-two. Former ballet dancer. No history of injury. Was perfectly well until she awoke one morning six months ago with pain in right hip and knee. She has since had mild symptoms in left hip. This roentgenogram shows evidence of circulatory disturbance in both femoral heads, with partial crushing of the right. It seems probable that the etiology in this case was the repeated small traumata incurred during her previous occupation as dancer.

Post-traumatic aseptic bone necrosis is not a rare condition, but, on the contrary, is encountered rather frequently in an active bone and joint service. Its most frequent occurrence is following fractures and dislocations. It is seen occasionally, however, following less serious injury, and we have evidence that it may occur as a result of repeated small traumata such as those

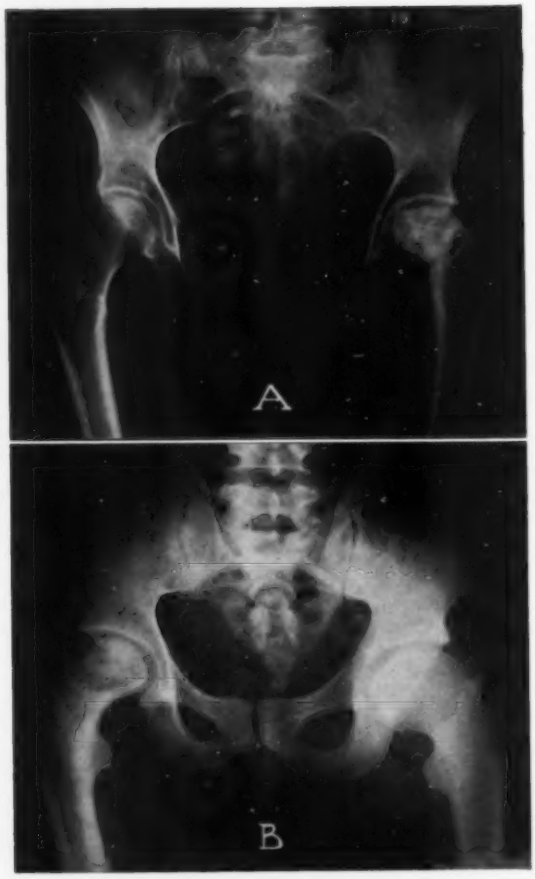


FIG. 4. A warning that other conditions may produce changes simulating aseptic necrosis. *A*, aseptic necrosis; *B*, proven Gaucher's disease.

incurred in ballet dancing. Such a case will be presented.

The most frequent site of occurrence appears to be the upper extremity of the femur, with the carpal bones, tarsal bones and ankle, and elbow in the order of frequency. The time of manifestation of the necrosis is probably variable, dependent on the many variables associated with the different types of trauma. In many instances circulatory changes are evident on the roentgenogram within a few months of the injury. In cases where the aseptic necrosis is not discovered until two or three years after the injury, it seems likely that the changes were present much earlier than this, but were perhaps not recognized. We shall show such a case.

The importance of recognizing the roentgen manifestations of circulatory disturb-

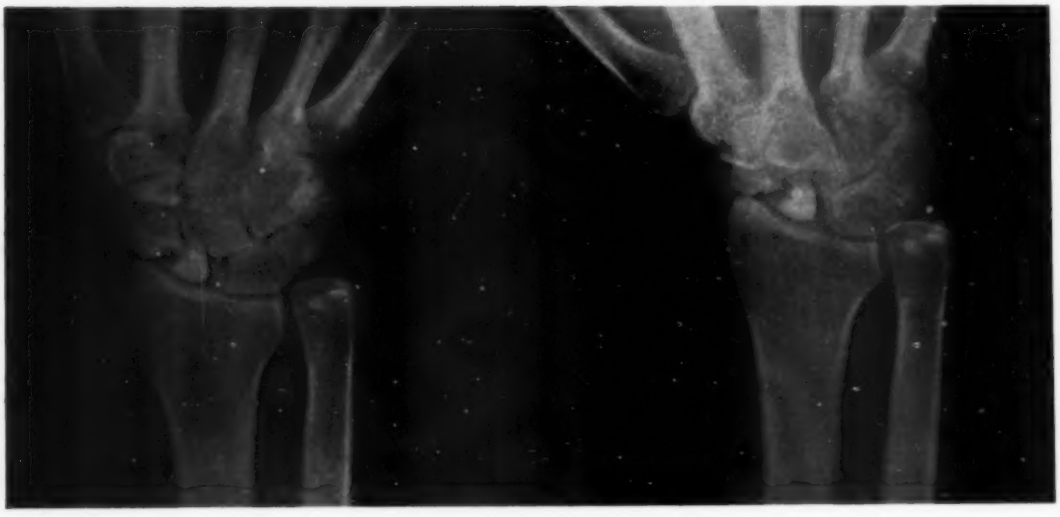


FIG. 5. Case IV. C.T., male, aged twenty-three. Fell from a tree July 17, 1937, sustaining a fracture of the carpal scaphoid. This was treated elsewhere in plaster for ten weeks. Roentgenograms showing non-union, the bone was drilled twice. When seen here February 16, 1938 (Fig. 5) there was non-union, wide separation of fragments, necrosis of the proximal fragment with no evidence of creeping replacement. The likelihood of re-establishing circulation and obtaining union and good function seemed poor. The proximal row of carpals was therefore excised.

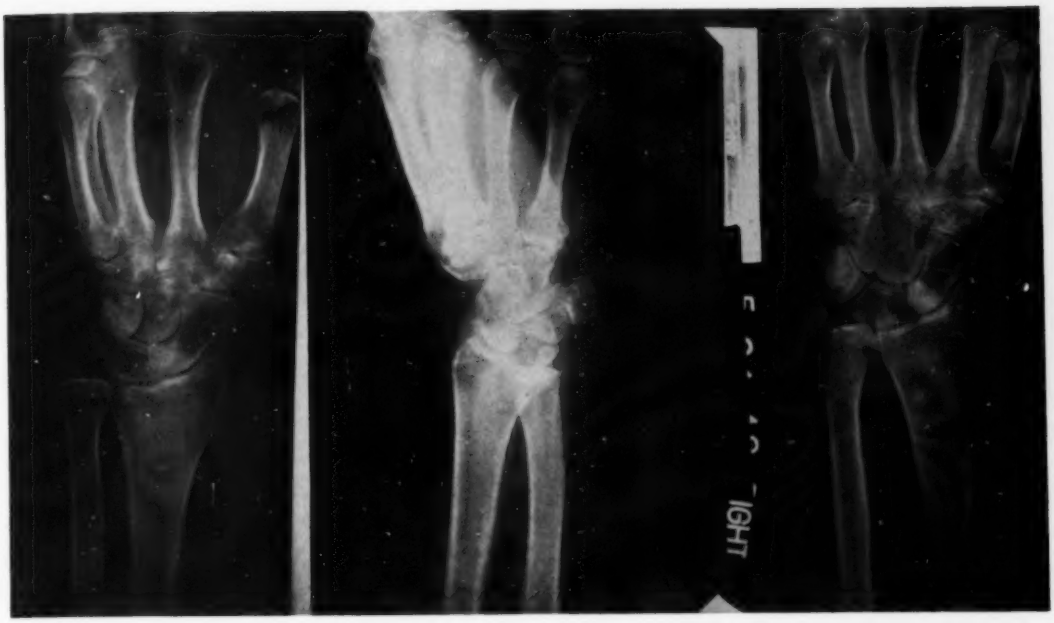


Fig. 6. Case v. M.McC., female, aged forty-eight. Fracture of carpal scaphoid March 1, 1940. Treated in plaster in cockup position for fourteen weeks. These roentgenograms show the condition May 24, 1940. There is evidence of circulatory deficiency in the proximal portion of the proximal fragment, but creeping replacement has occurred in this fragment along the fracture line, with evidence of union. The prognosis seems good.

Fig. 7. Case vi. J.M., male, aged twenty-four. November 24, 1937 suffered a dislocation of the lunate bone, but was treated elsewhere only by immobilization. Open reduction was performed in this hospital February 23, 1938. Examination April 14, 1938 (*A*) shows slight subluxation and aseptic necrosis of the lunate. Examination March 4, 1939 (*B*) shows necrosis with small scattered areas of creeping substitution. The prognosis appears unfavorable.

Fig. 8. Case vii. N.H., male, aged twelve. Was run over by car wheel October 31, 1940, injuring ankle. Was in another hospital under treatment for forty-seven days, allegedly for compound fracture of both bones. The wound was said to have closed about a week before he was discharged. These roentgenograms July 23, 1941, show old ununited fracture of the mesial malleolus. The distal epiphysis of the tibia shows irregularly increased density, with much flattening. The epiphyseal cartilage is still present. The ankle joint width is narrow, but not obliterated. The findings suggest aseptic necrosis of the lower tibial epiphysis, with considerable crushing and fragmentation.

Fig. 9. Case viii. S.T., male, aged sixty-five. On April 11, 1941, he fell from a roof, sustaining a compound fracture dislocation of the astragalus. Wound was contaminated with dirt, the astragalus seemed to be attached only by a thread. Treated by cleaning, débridement, tetanus antitoxin, sulfanilamide. Infection developed. These roentgenograms show the condition on September 11, with necrosis of the astragalus, probably largely aseptic in nature, with no evidence of creeping replacement. Later examinations showed some evidence of localized areas of creeping substitution, but the eventual outcome is still very uncertain.

Fig. 10. Case IX. A.B., female, aged six and a half. Was struck by a car, injuring ankle, and was treated in plaster in another hospital about seven weeks. These roentgenograms show the condition two and a half months after the injury. There is obvious aseptic necrosis of the body of the astragalus, with crushing of the body, probably secondary to the circulatory disturbance rather than produced by the original injury. There was little if any evidence of creeping replacement. The patient was treated conservatively, was followed a short time, then disappeared.

ance in bone is obvious. During the period of bone necrosis and creeping replacement, the strength of the bone is greatly diminished, and it cannot perform full function without danger of collapse, without danger of destruction of the anemic overlying articular cartilage. If these things occur, secondary osteoarthritis and a permanently damaged joint seem inevitable. If, on the other hand, the roentgenologist recognizes the existence of deficient blood supply, and the clinician protects the part and restricts function within safe limits, or perhaps carries out some operative procedure to improve circulation, the chances of eventual re-establishment of adequate circulation and restoration of the part to good function are greatly increased.

Figures 1 to 10 are presented showing cases illustrative of the conditions discussed.

SUMMARY AND CONCLUSIONS

(1) A brief summary has been given of the pathology and roentgenographic findings in post-traumatic aseptic necrosis of bone, as described by Phemister in a recent article.

(2) The importance of recognition of the condition by the roentgenologist, and of proper management of the case by the clinician, is discussed.

(3) Cases illustrating the condition are shown and discussed.

(4) As a warning, a case is presented demonstrating that other conditions may bear roentgenographic resemblance to aseptic necrosis.

EXTRAORDINARY CALCIFICATION IN THE BREAST*

By BENJAMIN W. ANTHONY, M.D., *and* HERBERT C. POLLACK, M.D.
CHICAGO, ILLINOIS

DURING our routine examinations we encountered a chest roentgenogram which, on the first observation, showed an unusual network of extreme densities in or on the right side of the thorax, as illustrated in Figure 1. It had the appearance of calcification of the entire right bronchial tree, but under the stereoscope the roentgenograms revealed these calcifications to be in the soft tissues anterior to the bony thorax. Therefore roentgenograms of the chest in the oblique diameter (Fig. 2) and of the right breast (lateral and oblique views—Fig. 3 and 4) were taken, demonstrating that these shadows were definitely situated in the right mamma.

FIG. 1. Right breast grossly enlarged. Calcifications projected through center of right side of thorax.

Because of the rarity of such findings, we decided to report this case.

The patient was a female, colored, aged sixty-six, who stated that her right breast was injured seventeen years ago by a blow, resulting in pronounced swelling with bluish discoloration and massive hematoma. The breast was extremely painful after the injury, gradually became hard, heavy, and remained so until the present time. She had not observed any remarkable change in the appearance of the breast within the past ten years. On examining the enlarged right breast (Fig. 5 and 6) we noted a heavy, cake-like mass, which measured approximately 2 inches in thickness and 4½ inches from the medial to the lateral borders. The firm mass felt as if it were composed of concrete. The breast was pendulous, freely movable over the underlying tissue, and so heavy that it had to be elevated and supported during our roentgenographic studies. There was no retraction of the nipple and the skin of the breast showed no pathological changes. The regional lymph nodes were not palpable; the surface of the breast was uniform and no pain was elicited on palpation.

FIG. 2. Extensive calcifications and ossifications within the right breast. Thoracic cage and lungs clear.

* From the Department of Roentgenology, Provident Hospital, Chicago

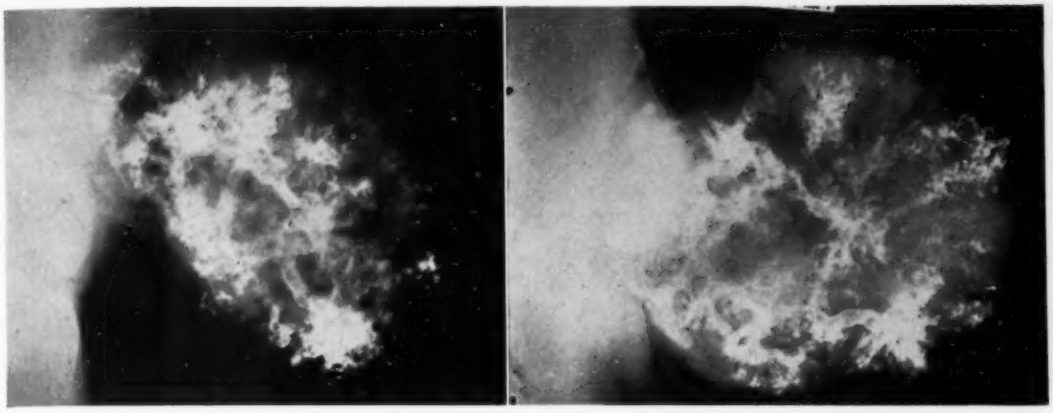


Fig. 3 and 4. Right breast. Oblique and lateral views. Radiating trabecular arrangement of ossifications and calcifications.

Ordinarily the breasts of a woman of this age are atrophic and this applied to the left mamma, which was normal. The roentgenograms showed pronounced calcifications involving almost the entire right breast, branching from the base to the periphery in a shrub-like manner. In the central portion ossification was present, radiating in all directions throughout the right breast, showing a tendency toward bone formation. The oblique as well as the lat-

Fig. 5 and 6. Frontal and oblique photographs of breasts. Right is grossly enlarged and pendulous, whereas the left one is atrophic.

eral views of the breast revealed that the calcification extended from the soft tissue and did not involve the bony cage.

The literature of the last ten years discloses that roentgen examinations of the breast have been of diagnostic value in differentiating between benign and malignant lesions of the breast. There are numerous conditions followed by calcification in the breast, the most frequent of these being healed mastitic abscesses. In addition, calcification may occur or be associated with the following affections:

1. Adenoma
2. Cyst
3. Hematoma
4. Mammary tuberculosis
5. Psammocarcinoma
6. Necrotic areas of mammary carcinoma
7. Calcinosis universalis
8. Osteitis deformans

Calcium deposits may be in any part of the breast, in the subcutaneous and fatty tissue, in the parenchyma, or in the "milk ducts" radiating from the nipple to the base of the breast.

Calcifications in carcinomatous tissue, however, are extremely rare whereas our observations confirm the fact that calcareous deposits are relatively common in benign lesions.

SUMMARY

A case is presented exhibiting extensive calcification of almost the entire right breast in a female aged sixty-six. Presumably these changes were the result of trauma and hematoma formation having occurred seventeen years previously. This is the most extensive calcification we have been privileged to see in our experience.

REFERENCES

1. FINSTERBUSCH, R., and GROSS, F. Kalkablagerungen in den Milch- und Ausführungsgängen beider Brustdrüsen. *Röntgenpraxis*, 1934, 6, 172–174.
2. LEDOUX-LEBARD, R., GARCIA-CALDERON, J., and ESPAILLAT, A. Étude radiographique de la glande mammaire. *Bull. et mém. Soc. de radiol. méd. de France*, 1933, *21*, 418–432. Abs. AM. J. ROENTGENOL. & RAD. THERAPY, 1935, *33*, 265.
3. LOCKWOOD, I. H. Roentgen-ray evaluation of breast symptoms. AM. J. ROENTGENOL. & RAD. THERAPY, 1933, *29*, 145–155.
4. PASCHETTA, V. Étude radiologique de la glande mammaire. *Bull. et mém. Soc. de radiol. méd. de France*, 1931, *19*, 346–348. Abs. AM. J. ROENTGENOL. & RAD. THERAPY, 1933, *29*, 553.
5. REMY-ROUX. Sur un cas de granulations calcaires sous-cutanées. *Bull. et mém. Soc. de radiol. méd. de France*, 1932, *20*, 437–440. Abs. AM. J. ROENTGENOL. & RAD. THEARPY, 1933, *30*, 567.
6. WARREN, S. L. Roentgenologic study of the breast. AM. J. ROENTGENOL. & RAD. THERAPY, 1930, *24*, 113–124.

VOL. 49, NO. 5

OSTEOPOIKILOSIS*

A CASE REPORT

By ROY H. THOMPSON, *Lieutenant Colonel, Medical Corps, Army of the United States*
RUBEN HOOVER, *Major, Medical Corps, Army of the United States*
FORT HAYES, OHIO
and
HUSTON F. FULTON, M.D.
COLUMBUS, OHIO

THE following case of osteopoikilosis (osteopathia condensans disseminata) is presented because of the apparent rarity of this entity and because this case may aid in furthering its study.

On October 31, 1941, the Selective Service Examining Board at Fort Hayes, Columbus, Ohio, was confronted with another problem. This was in the form of a husky, well built, well nourished applicant, J.B.L., who complained, as did so many others, of vague pains. These were localized to the right hip and right knee. He was given the usual tests and no deformity or limitation of motion or areas of tenderness were noted. He was given the benefit of the doubt and referred to the roentgen-ray clinic at the Station Hospital. The diagnosis of osteopoikilosis was returned and the applicant admitted on November 1, 1941, for further study.

The applicant was a white male, aged twenty-seven, and weighing about 180 pounds, and was a native Ohioan. After leaving the seventh grade at the age of sixteen he worked on his father's farm. He was an occasional user of alcohol and tobacco. No history of drug addiction was admitted. About two years previous to his admission he stated that after a hard day of work he noticed a heavy feeling in his right leg and a dull ache in the right hip. This pain would disappear after a night's rest. No trauma was remembered which could account for the onset of the pain. Since then every day that the work was particularly heavy the ache would return. There seemed to be no difference in the severity of the pain felt on admission as compared with that at the onset. The history taken on admission revealed that the father was living and well at sixty-three years of age. The mother had died of tuberculosis at the age of sixty-three. Three brothers and two sisters were living and well. Among the childhood diseases recalled

FIG. 1. Osteopoikilosis. The dense circumscribed areas are diffusely scattered through the carpal bones but are confined to the ends of the long bones.

FIG. 2. The dense circumscribed areas are present in the body of the fifth lumbar vertebra, sacrum, pelvis, and upper end of the shafts of the femurs, concentrated more at the weight-bearing points.

* Published with permission of the Surgeon General who is not responsible for any opinion expressed or conclusions reached herein.

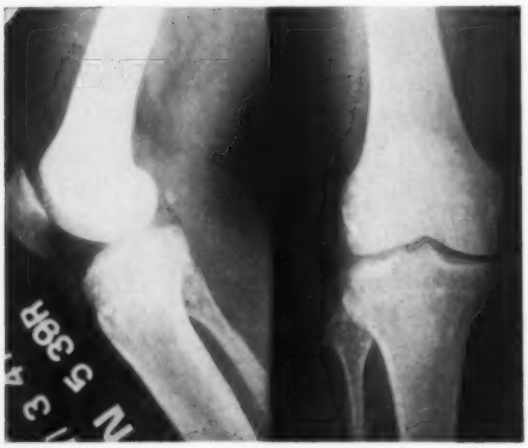


FIG. 3. Areas of osteopoikilosis noted in and near the articular surfaces of the tibia, fibula, femur, and patella.

were measles, mumps and whooping cough. No serious operations or injuries were remembered.

The physical examination was essentially negative. The eye grounds were normal. The cardiovascular system was normal and the blood pressure 134/85. The prostate gland was normal. No lymphadenopathy was present. The reflexes were normal.

The laboratory report revealed a blood calcium of 15.6 mg. per 100 cc. The blood phosphorus determination was unsatisfactory and owing to brevity of the time available for the study, the test was not repeated. The blood sugar was 85 mg., non-protein nitrogen 30 mg., and chlorides 220 mg. per 100 cc. The blood study showed 4,860,000 red blood cells, 6,900 leukocytes and a hemoglobin of 90 per cent. The differential count showed 60 per cent polymorphonuclears, 37 per cent lymphocytes and 3 per cent eosinophiles. The Kahn test was negative. Urinalysis was negative for albumin; a trace of sugar was found. The urine was straw colored, clear, acid, and microscopically negative.

The roentgen report was as follows: *Skull:* Right lateral stereoscopic view shows the sella to be small and bridged. No evidence of osteopoikilosis*. *Chest:* Small mass of calcified right paratracheal nodes measuring about 1.5 cm. in diameter. Calcified primary tubercle in right apex. No evidence of activity or of reinfection type tuberculosis. No evidence of osteopoikilosis. *Pelvis:* Small dense sharply demarcated areas present throughout pelvis including upper ends of femurs and fifth lumbar vertebra, more numerous near the joint surfaces, and not elevated above the surface of the bone, measuring from 2 to 5 mm. in diameter. *Knees:* Small dense sharply demarcated areas present in cortex of diaphysis and epiphysis, most numerous in the latter, of all bones in both knees including the patellae. *Feet:* Similar areas present mainly near the articular surfaces of the long bones and scattered uniformly through the tarsal bones. *Hands:* Similar areas present in the bones of both hands†.

Ferguson[1] states that defective bone formation in the metaphysis takes the form of dense non-reticulated calcareous matter. The central intermittent defect of this type gives rise to a persistent, dense, structureless area in the bone, sometimes small and rounded, characterized by abrupt transition from normal apparently healthy bone to absence of reticulation in the dense area. When this is diffuse, widespread, and abundant it is called osteopoikilosis. These defects are innocuous.

FIG. 4. Similar distribution of osteopoikilosis involving both feet.

* The sella turcica measured 8 mm. in the anteroposterior diameter and was 6 mm. deep, at a 30 inch film tube distance.

† Since submission of the paper the father was roentgenographed for study of the pelvis and long bones and the roentgenograms showed no evidence of osteopoikilosis.

According to Hirsch's[2] classification, this case would be of the nodular variety. Nichols and Shiflett[4] described a case complicated by hypopituitarism, in which the sella turcica, as in this case, was small but otherwise normal. Several investigators have verified its hereditary tendency; among them are Wilcox,[6] Sutherland,[5] and Lowrey and Booth.[3]

This case was apparently free of complications although a definite slight mental deficiency was noted. The fact that the mother died of tuberculosis may be of some significance.

An unsuccessful attempt was made to have the family undergo physical and roentgen examination. This applicant was rejected because of his joint pains which were believed to be severe enough to preclude full military service.

REFERENCES

1. Ferguson, A. B. Roentgen Diagnosis of the Extremities and Spine. *Ann. Roentgenol.*, Vol. xvii. P. B. Hoeber, Inc., New York, 1941.
2. Hirsch, I. S. Osteopoikilosis. *Radiology*, 1935, *25*, 349–354.
3. Lowrey, J. M., and Booth, J. H. R. Osteopathia condensans disseminata: "spotted bones." Am. J. Roentgenol. & Rad. Therapy, 1937, *37*, 774–781.
4. Nichols, B. H., and Shiflett, E. L. Osteopoikilosis. Am. J. Roentgenol. & Rad. Therapy, 1934, *32*, 52–63.
5. Sutherland, C. G. Osteopoikilosis. *Radiology*, 1935, *25*, 470–479.
6. Wilcox, L. F. Osteopoikilosis (disseminated condensing osteopathy). Am. J. Roentgenol. & Rad. Therapy, 1932, *27*, 580–584.

THE ROENTGEN TREATMENT OF CANCER OF THE ESOPHAGUS

By D. W. SMITHERS, M.D., D.M.R., J. R. CLARKSON, PH.D., *and* J. A. STRONG,* M.Sc.
From the X-Ray and Physics Departments of the Royal Cancer Hospital (Free)
LONDON, ENGLAND

INTRODUCTION

By D. W. Smithers

THERE are good reasons for believing that the treatment of cancer of the esophagus should meet with more success than it has done in the past. One of the essentials for such progress is an understanding of the peculiar difficulties which are associated with the treatment of this disease. Improvement is only to be expected if we can take steps to eliminate or minimize the effects of many of the factors that have contributed to our past lack of success.

Reasons for Failure of Treatment Due to the Nature of the Disease.

1. The great majority of patients with cancer of the esophagus do not receive any treatment until the disease has been present for many months.

2. The esophagus is a thin-walled, deep-seated tube, which may be extensively involved by the tumor and which lies in close relation to vital structures, perforation into which results in rapid death.

3. A cancer of the esophagus is often a highly malignant growth which, although the majority remain localized for a few months, tends to rapid and widespread dissemination in the later stages.

4. Esophageal obstruction leads to starvation and such rapid deterioration in the patient's general health that his ability to withstand the strain of any radical treatment is seriously impaired.

The disease is often well advanced by the time that it causes sufficient obstruction for the patient to notice difficulty in swallowing. As dysphagia is the commonest initial symptom it is seldom possible to make the diagnosis at an early stage. It is therefore all the more important that treatment be started without delay once symptoms have appeared. At present there is a gap of several months before the majority of these patients reach the hospital (Table 1). The chances of success with any treatment must undergo a serious deterioration during this wasted period.

TABLE I

AVERAGE DURATION OF SYMPTOMS BEFORE ADMISSION TO HOSPITAL

Observer	Time in Months
Abel[1]	6 to 8
Souttar[29]	5.2
Broders and Vinson[5]	7.0
McGibbon[18]	3.4
Present series	4.1

In general the difficulties with any form of treatment increase with the size of the tumor. In many of these cases a considerable length of the esophagus is involved. In 2 of the untreated cases in the present series a tumor 7.5 cm. in length was found at autopsy after a period of six months' dysphagia. In another the patient had had symptoms for four months and two ulcers were found, one 4.5 cm. long and the other 11 cm. long, separated by a small piece of apparently normal mucous membrane. Buchbinder[6] examined 33 cases where the average duration of symptoms had been five and one-half months and found that the average length of esophagus involved was 7.5 cm. Fleming[10] found tumors of an

* We regret that since the completion of the text of this paper, J. A. Strong was killed on active service with the Royal Air Force. Mr. Strong was physicist to the New Zealand Branch of the British Empire Cancer Campaign, and his death is a severe loss to medical radiology.

average of 5.4 cm. in length in 34 cases. The relationship between the size of the tumor and the duration of symptoms in his cases is shown in Table II.

Table II (Fleming[10])

RELATIONSHIP BETWEEN SIZE OF PRIMARY GROWTH AND DURATION OF SYMPTOMS BEFORE DEATH

Size up to:	Cases	Average Survival in Months from Onset of Symptoms
2.5 cm.	2	4.5
2.5– 5.0 cm.	12	5.5
5.0– 7.5 cm.	13	5.4
7.5–10.0 cm.	5	5.3
10.0–12.5 cm.	2	5.8

Esophageal tumors tend to be of the less well differentiated, more highly malignant grades. McGibbon[18] collected some figures showing the proportion of cases in each grade (Table III). The more undifferentiated the tumor the greater its tendency

Table III (McGibbon[18])

Observer	No. of Cases	Grade 1	Grade 2	Grade 3	Grade 4
Broders and Vinson[5]	207	0	16	95	96
Watson[33]	202	15	148	39	0
Clayton[9]	39	3	15	12	9
Percentages	—	4%	40%	32.5%	23.5%

to rapid dissemination. Clayton[9] collected data to demonstrate this point (Table IV). The length of time that symptoms have been present must be considered together with the grade of the tumor in assessing the chances that distant metastases are present. The importance of the length of history in this respect was stressed by Helsley.[12] The average duration of symptoms in his patients who died without demonstrable metastases was 4.84 months. Those patients of his who had had a gastrostomy lived an average of sixty-nine days longer than the remainder, and the percentage with metastases rose during this period from 18 to 43. In the present series postmortem examinations were carried out in 13 (7 treated and 6 not treated or incompletely treated). No metastases were found in 4 who had lived an average of five months since the onset of symptoms but metastases were found in nine that had lived an average of 9.1 months.

The great majority of these patients on arrival at the hospital are already weak and wasted, most of them have extensive involvement of the esophagus, many have distant metastases and some may be expected to perforate before any adequate

Table IV (Clayton[9])

INCIDENCE OF DISTANT METASTASES ACCORDING TO THE GRADE OF TUMOR AND DURATION OF SYMPTOMS

Grade	No. of Cases	Average Duration of Symptoms before Death in Months	No. of Cases with Metastases
1	3	16	1 (33.3%)
2	15	8	10 (66.7%)
3	12	5	10 (83.3%)
4	9	2.5	9 (100%)

treatment can be given. So long as the present delay in starting treatment persists nothing more than an occasional success can be expected with any treatment.

There is probably little that can be done to persuade these patients to report their symptoms earlier, but the removal of the impression held by so many practitioners that no benefit results from treatment may help to speed their progress to a hospital. There is evidence that success can be achieved in an increasing proportion of cases, and much can be done to relieve symptoms and prolong life. One has only to see a few of these patients able to swallow normally once more to be convinced of the value of treatment on this score alone. Great care should be taken in the examination of any patient who has symptoms that might be due to a cancer of the esophagus. As soon as the diagnosis is made every precaution must be taken to avoid local trauma which may increase the risk of perforation. It is important that these patients

should receive adequate nourishment.

A case recently published by Bendick[4] is a good example of what can be achieved with early diagnosis and treatment. In this case the diagnosis was made and confirmed microscopically before obstruction had occurred and the patient was alive, well and working two and one-half years after Garlock had resected the esophagus. The tumor was found to be but 2.0 by 1.4 cm. in size.

Particular Difficulties Associated with the Various Methods of Treatment.

1. *Surgery.* The surgical removal of esophageal tumors carries a high operative mortality and is still only applicable to a very small proportion of cases. Adams and Phemister[2] in 1938 collected the published cases of successful removal of tumors of the thoracic and abdominal esophagus and could find only 36 from 1907. Of these 36 only one lived more than five years. This oft quoted and fascinating case was published by Torek.[31,32] The patient lived for thirteen years and then died of intercurrent disease. It is of interest to note that this one success was achieved in a most unusual case for the growth had remained localized despite the fact that symptoms had been present for as long as nine months. The risks of operation and the past lack of success even with selected cases suggests that surgery is only indicated for some tumors of the cervical portion of the esophagus or where exceptional circumstances are present.

2. *Teleradium.* Owing to the inadequate depth dose obtainable with the teleradium units at present in use, this method of treatment is not suitable for deep-seated tumors. (Five gram teleradium unit $d\frac{1}{2}$ = 3.4 cm.; 400 kv. roentgen unit used as described in text $d\frac{1}{2}$ = 7.1 – 7.9 cm.) ($d\frac{1}{2}$ is the depth below the surface along the central axis of the beam at which the dose is 50 per cent of that received on the surface.) As far as the esophagus is concerned teleradium therapy must be confined to tumors of the cervical portion.

3. *Interstitial radium or radon.* The implantation of radium or radon cannot be carried out accurately through an esophagoscope; the instrument distorts the tissues and the seeds can only be inserted obliquely. It is almost impossible to place the radon so as to obtain an even irradiation of the whole tumor. The trauma and local high dosage inherent in this method increase the risk of perforation. It is only of value where surgical exposure can be obtained comparatively easily, as in the case of tumors of the fundus of the stomach which involve the lower limit of the esophagus.

4. *Radium bougie.* The best results have so far been obtained by the use of the radium bougie. The outstanding exponent of this form of treatment is Guisez. Some of his results are quoted by Watson[33] (Table v). Guisez[11] also refers to one of his patients who lived for twenty-six years after treatment. Lawrence Abel has shown the present writer the unpublished records of one of his patients, treated at the Royal Cancer Hospital in April, 1927, who died of intercurrent disease in December, 1938.

TABLE V (Guisez)

RESULTS OF INTRA-ESOPHAGEAL RADIUM TREATMENT OF 270 CASES OF CARCINOMA OF THE ESOPHAGUS

1	alive 11 years after treatment
1	alive 10 years after treatment
1	alive 5 years after treatment
4	alive 4 years after treatment
4	alive 3 years after treatment
12	alive more than 18 months after treatment without evidence of disease

4 died of intercurrent disease without evidence of recurrence.

The disadvantages of the radium bougie are the difficulty in passing the upper limit of the obstruction, the rapid fall off of dose with depth, and the local trauma and high dosage which increase the risk of perforation. Zuppinger[34] treated groups of these patients with radium bougies, roentgen irradiation and combinations of the two. He found that the incidence of perforation

was higher with intra-esophageal radium and obtained the best results with roentgen irradiation alone.

5. *Roentgen irradiation.* Zuppinger[34] reported that 2 of his patients were alive, well and symptom free two and one-half years after roentgen treatment. Nielsen[25] attempted to give an adequate tumor dose in 17 cases, 8 of these lived more than one year, 2 were alive and symptom free at the end of three and one-half years and one at two and one-half years. Malcolmson and Malcolmson[19] reported one patient alive and well three years and Baum[3] one six years after treatment. Hilton[13] published particulars of a case in 1937 that had survived over three years and she informs me (July, 1940) that this patient is still alive and well. The disadvantages of roentgen irradiation are that a large volume of normal tissue must be irradiated, that damage may be done to these tissues and that the tumor dose which can be given is limited by the total energy absorption that the patient will tolerate.

The Advantages of Roentgen Treatment.

Roentgen treatment has much to recommend it for it is the most effective method of securing palliation and at the same time causes the patient least discomfort. These considerations are of great importance in a group of patients in which only a limited success can be expected. Roentgen treatment allows of an even irradiation of the whole tumor without local trauma. Measures can be adopted to overcome, in part, the main disadvantages of the method. To obtain a maximum tumor effect for a minimum damage to normal structures, it is essential to pay very careful attention to obtaining the optimal distribution of the radiation in the whole volume irradiated. This can be done by studying the three-dimensional distribution of the radiation due to various field arrangements and attention to the detail of the accurate application of the final fields selected. By such means we may hope to deliver an adequate tumor dose without overstepping either the limit of total energy absorption that the patient can tolerate or the dose to normal tissues that will cause serious damage. Recent work at the Royal Cancer Hospital has been concerned both with volume distributions of radiation[14] and with total energy absorption.[23] This work has now been applied to the problem of the roentgen treatment of cancer of the esophagus. The results obtained not only show that palliation and prolongation of life can be obtained in many cases, but also that the disease can be eradicated in some cases if the patients are treated early enough.

The assessment of the relative values of the various methods of treatment is a matter of extreme interest. If comparison is to be made complete accounts of all patients seen whether treated or not must be published for each method adopted. The purpose of the present paper is to describe in detail the method of roentgen treatment employed at the Royal Cancer Hospital and to give an account of the subsequent history of all cases seen from 1936 to 1939.

PART I

DESCRIPTION OF THE METHOD OF ROENTGEN TREATMENT ADOPTED AT THE ROYAL CANCER HOSPITAL AND AN ACCOUNT OF THE RESULTS OBTAINED

By D. W. Smithers

Classification. After the patient has been carefully examined and an esophagoscopy and a roentgenological examination performed we may, by taking into consideration the patient's general health, the length of history, and the degree of differentiation of the tumor, arrive at a fairly accurate assessment of the chances that the patient will benefit materially from treatment. As some palliation is to be expected in the majority of cases, treatment should be attempted whenever possible, but at times it is clear from the start that little or nothing can be done. In the present series treatment was started whenever the patient was well

enough to be brought to the department and could remain still supported in a sitting position for approximately one hour each day. If treatment was started at all the patient was placed in the treated group but a distinction was made between those that did and did not complete the treatment prescribed. The patients, therefore, were divided as follows:

1. Not treated.
2. Treated
   (a) completed treatment.
   (b) failed to complete treatment.

The arrangement of fields adopted for the treatment of tumors of the upper limit of the esophagus was the same as that employed for postcricoid tumors of the pharynx, and the arrangement for the lower limit of the esophagus was the same as that for tumors of the stomach in the region of the cardia. From a roentgen treatment point of view these cases were therefore divided according to the site of the tumor as follows:

1. Postcricoid tumors and tumors of the cervical esophagus.
2. Tumors of the thoracic esophagus.
3. Tumors of the abdominal esophagus and of the fundus of the stomach involving the esophagus.

Tumors of the esophagus were also divided according to the third of the organ in which the main body of the tumor lay for comparison with other work. McGibbon[18] took the mean percentages for each third from seventeen published series and found 17 per cent upper third, 47 per cent middle third and 36 per cent lower third tumors. It is probable that this represents a rather high percentage of lower third tumors. The majority of the tumors involving the lower limit of the esophagus are primary tumors of the stomach which invade the esophagus. In many cases the gastric portion of the tumor can be demonstrated roentgenologically. Histological examination is also helpful but adenocarcinomata do occasionally arise from "cardiac glands" in the esophageal mucosa or from patches of ectopic gastric epithelium.

Tumors of the Thoracic Esophagus.

1. *Preparation of the patient and care during treatment.* Whenever possible an esophagoscopy is performed before treatment is started and a piece is taken for biopsy so that the diagnosis can be confirmed and the degree of differentiation of the tumor determined.

If esophageal obstruction is almost complete, and the patient can swallow nothing but sips of fluid, a preliminary gastrostomy is performed. It is not done as a routine, as even this operation has a certain mortality in this group of weak and debilitated patients, and swallowing improves in the second week of roentgen treatment in nearly every case.

A calorie chart is kept for each patient to show the daily food intake, to serve as a guide to progress, and to impress the nursing staff with the importance of adequate nourishment. Each patient is weighed at regular intervals. Figure 1 is a dose, weight, blood count and calorie chart for an actual patient during the treatment period. The diet must be a fluid one in most cases, at any rate for the first two or three weeks. It should be given in small frequent, concentrated feeds containing a good proportion of protein and having a high vitamin content. Feeds should be given at least at three-hour intervals during the day and once during the night if the patient is awake.

All these patients should be in hospital throughout their treatment. It is important to see that they get adequate rest and to keep a check on the temperature and pulse rate. Levitt[17] has pointed out the importance of the pulse rate; a persistently rapid pulse, usually without pyrexia is regarded by him as the first sign of mediastinitis and of serious import. We have been able to confirm this in several cases. Patients with severe and persistent tachycardia seldom complete their treatment and rarely survive it by more than a few weeks.

This tachycardia may be followed by substernal pain, with fever in some cases, and commonly ends with perforation of the esophagus.

It is important to keep a record of the variation in the patient's blood count, for it is here that the first indication appears that the patient's tolerance to large volume must be taken to raise it; the most effective means is to stop treatment for a few days. This is to be expected for the drop in the white cell count is partly due to a destruction of circulating lymphocytes. The problem is an important one for the leukopenia produced is a major obstacle in the way of adequate roentgen treatment. Carrié[7]

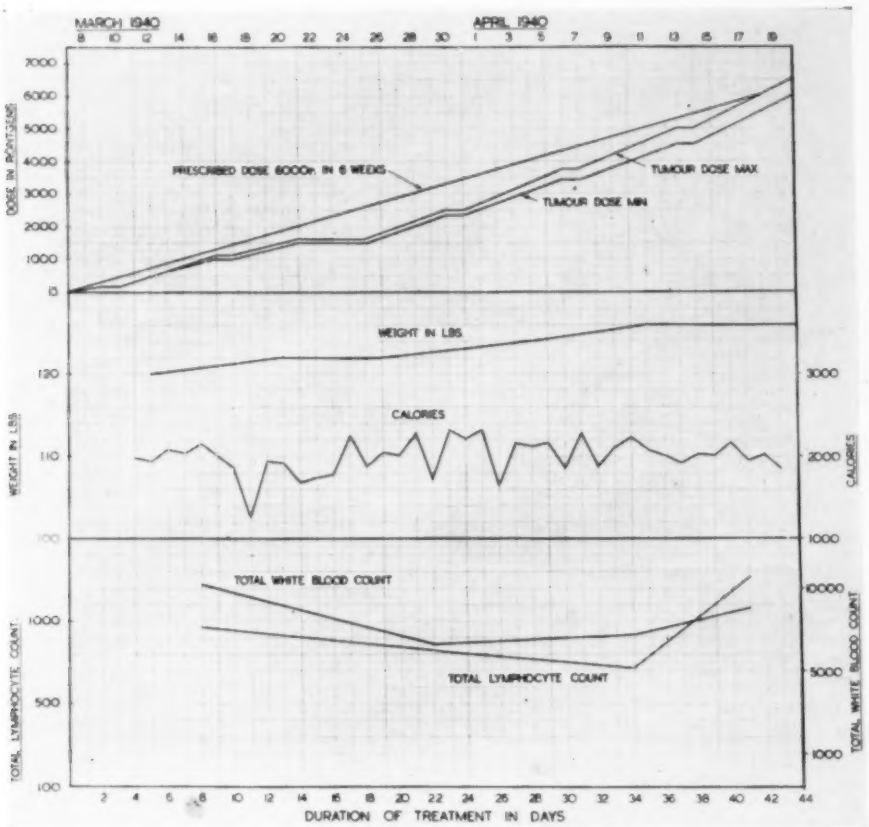


Fig. 1. Tumor dose, weight, calorie and white blood count chart. The record of an actual case during the treatment period.

irradiation is failing. Blood counts are therefore carried out before treatment and at weekly intervals throughout the course or more frequently if necessary. With such a fatal disease risks may be taken so we do not stop treatment unless the total white cell count falls below 2,000 cells per c. mm. or the lymphocytes below 200 cells per c. mm., and the treatment is continued as soon as the blood count improves. When this drop in the blood count occurs measures quotes the work of Friemann who found that experimentally produced leukopenia in animals could be eliminated or prevented by the administration of vitamin C. Carrié tried the effect of vitamin C on roentgen leukopenia and concluded that it had a favorable influence, particularly if administered throughout the course of irradiation. We have given 1,000 units of ascorbic acid two or three times a day to a number of the patients in the present series

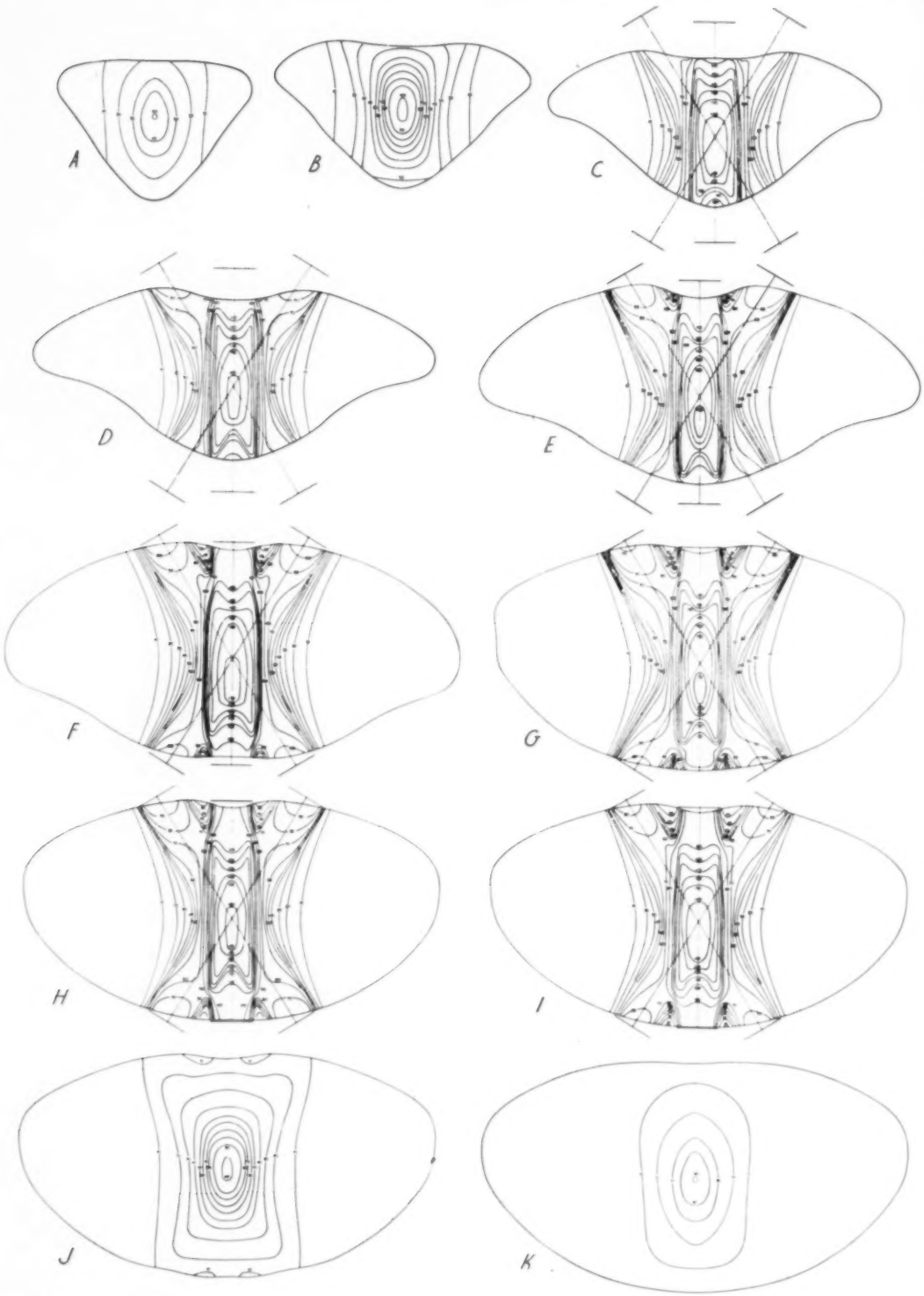


FIG. 2. Volume distribution in an average patient. Six fields 20×4 cm., 80 cm. focus-skin distance, 400 kv. (peak), 3.7 mm. Cu half-value layer. *A*, plane 12 cm. up from center; *B*, plane 11 cm. up from center; *C*, plane 10 cm. up from center; *D*, plane 8 cm. up from center; *E*, plane 5 cm. up from center; *F*, central plane; *G*, plane 5 cm. down from center; *H*, plane 8 cm. down from center; *I*, plane 10 cm. down from center; *J*, plane 11 cm. down from center; *K*, plane 12 cm. down from center.

and, though it is too soon to gain any clear impression of the result, we have been sufficiently encouraged to continue its trial. In certain cases the lymphocyte count after the usual initial fall has actually risen towards the end of treatment (see Fig. 1). Incidentally it has been found by Imler and Wammock[15] that irradiation nausea is sometimes controlled by the administration of large doses of vitamin B_1. There is certainly room for further work on the effects of a high vitamin diet for patients undergoing radiation therapy.

The effect of irradiation on the red blood cells is not so serious, but if the patient is already anemic large doses of iron are given or a blood transfusion carried out before treatment starts and repeated if necessary. Iron is also given to those women who have a history of idiopathic hypochromic anemia.

2. *Selection of the treatment fields.* The size, shape, number and positions of the treatment fields that are employed should be such that the best possible distribution of the radiation is obtained throughout the volume irradiated. The ideal distribution for tumors of the thoracic esophagus is one that results in the highest dose being delivered to a cylinder of tissue that includes the length of the esophagus involved by the growth, and at the same time delivers as small a dose as possible to the more sensitive of the normal structures in the thorax. As shown in the introduction, the length of esophagus involved may be considerable and is nearly always greater than that indicated by roentgen examination. To obtain an adequate tumor dose multiple fields must be used, and it is clear that long narrow fields will give the best distribution. Levitt[16] used five to eight fields measuring 16.5 × 5 cm. At first he spaced these fields widely around the chest wall but found that a diffuse fine fibrosis of the lungs with spasmodic cough and dyspnea resulted. To avoid this he either concentrated his fields round one side of the chest to limit the fibrosis to one lung or placed them all near the midline to avoid the lungs as far as possible. Roberts[28] used fields measuring 15 × 2.5 cm., sometimes employing as many as twenty-six of these strips arranged round the whole thorax.

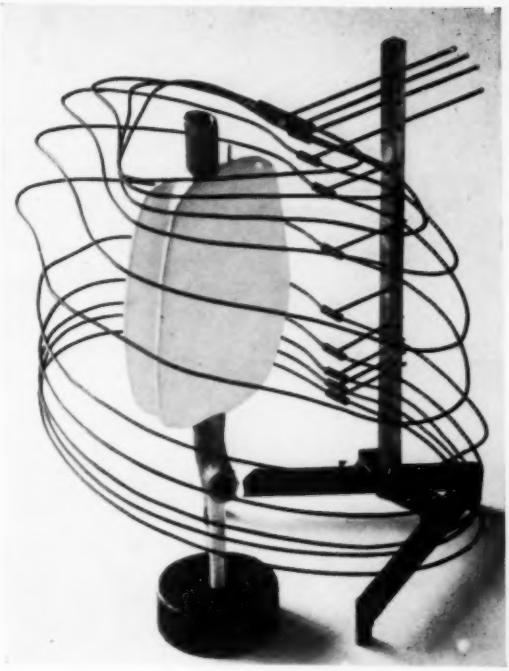


Fig. 3. Model of the average patient showing the relative positions of the cross sections in Figure 2, and the shape and position around the esophagus of the 140 per cent isodose surface.

The first few cases in the present series were treated with four fields, two in front and two behind, placed close to the midline and measuring 11 × 7 cm. It was found that this number of fields was too few as severe skin reactions were produced and too large a volume of tissue received the high dose. The fields were also too short in some cases for although local tumor regression occurred extension took place below the treatment field level. After discussions with other radiotherapists it was decided to use fields measuring 20 × 4 cm. ($d\frac{1}{2} = 7.5$ cm.). A number of arrangements of fields of this size were tried and the distribution due to them in the central plane determined. From a study of these distribution charts the following scheme was adopted.

Six fields were employed arranged in three sets of directly opposing pairs: a

direct anteroposterior pair and two oblique pairs near the midline. The center of each anterior oblique field was placed 6 cm. from the center of the direct anterior field. The position of the posterior fields was such that the central ray of each directly opposing field pair passed through the tumor.

Mid-plane distribution charts are of value in helping to decide on an arrangement of fields but do not give the necessary information as to the distribution of the radiation in planes above and below this level. To decide finally on the best arrangement of fields, it is necessary to determine the complete three-dimensional or volume distribution on the lines of those already published by Honeyburne, Lamerton, Smithers and Mayneord.[14] While this is a comparatively simple matter for arrangements of circular fields it becomes more complicated when strip fields are used. The method adopted in obtaining the volume distribution due to these fields is described in Part II. The distributions were drawn in several parallel horizontal planes on cross sections obtained by taking an average of the dimensions of all the patients with cancer of the esophagus who had been treated during the past two years.

From a study of the three-dimensional distribution it was clear that the arrangement of six strip fields already described fulfilled most of the requirements laid down at the beginning of this section. It was found that the fall off in dose at the midpoint in planes above and below the center was of little consequence until a level just short of the length of the fields was reached. This is due to the fact that the isodose curves for each field are remarkably flat over the greater part of their length (see Fig. 17). This again is partly due to the high voltage (400 kv.) and also to the use of a long focal skin distance (80 cm.) which

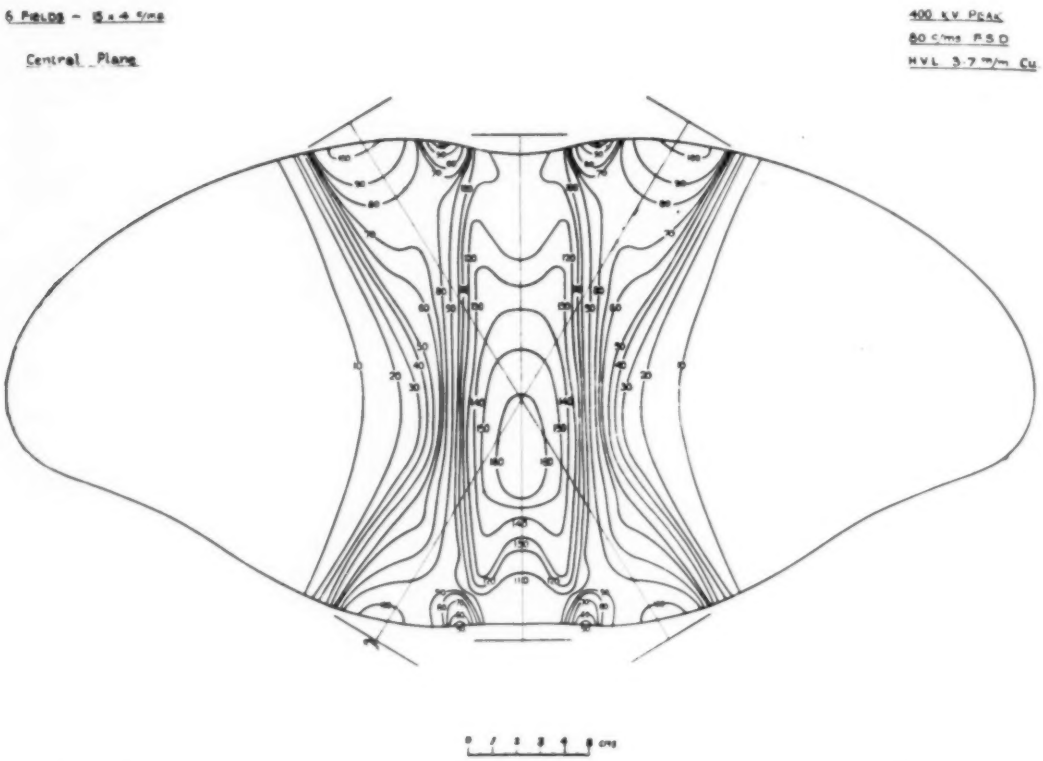


FIG. 4. Central plane distribution for conditions similar to those shown in central plane Figure 2, with the exception that the length of the fields is reduced from 20 cm. to 15 cm.

have been adopted for this purpose. It was at once obvious that the length of the fields could be reduced without loss of efficiency in irradiating the primary tumor and with a gain in so far as the total energy absorption in the patient, the "integral dose," would be less. The volume distribution also showed that instead of the desired cylinder of high dosage around the tumor this volume was seriously flattened from side to side; in other words, the dose fell off rapidly on either side of the mid-point of the tumor (Fig. 2). Figure 3 shows the relative positions of the cross sections in Figure 2, and the shape and position around the esophagus of the 140 per cent isodose surface.

In order to correct these points and yet not increase the dose to the lungs the distributions due to new arrangements and sizes of field were determined. First the length was reduced to 15 cm. but the arrangements otherwise preserved (Fig. 4). Then the width of the two central fields was increased to 6 cm. to broaden the central high dose region (Fig. 5). Finally the centers of the two anterior oblique fields were moved out to a position 7 cm. from the midline on either side (Fig. 6). A study of these distribution charts shows the reasons for these steps and the advantages of the final arrangement selected.

The arrangement of fields now adopted, therefore, is as follows: six fields in three directly opposing pairs; an anteroposterior pair measuring 15×6 cm. each ($d\frac{1}{2}=7.9$ cm.) and two oblique pairs measuring 15×4 cm. each ($d\frac{1}{2}=7.1$ cm.); fields so arranged that the center of each anterior oblique field is 7.0 cm. from the midline and the central rays from all six fields meet at the center of the tumor.

The total energy absorption in the different techniques may be calculated by meth-

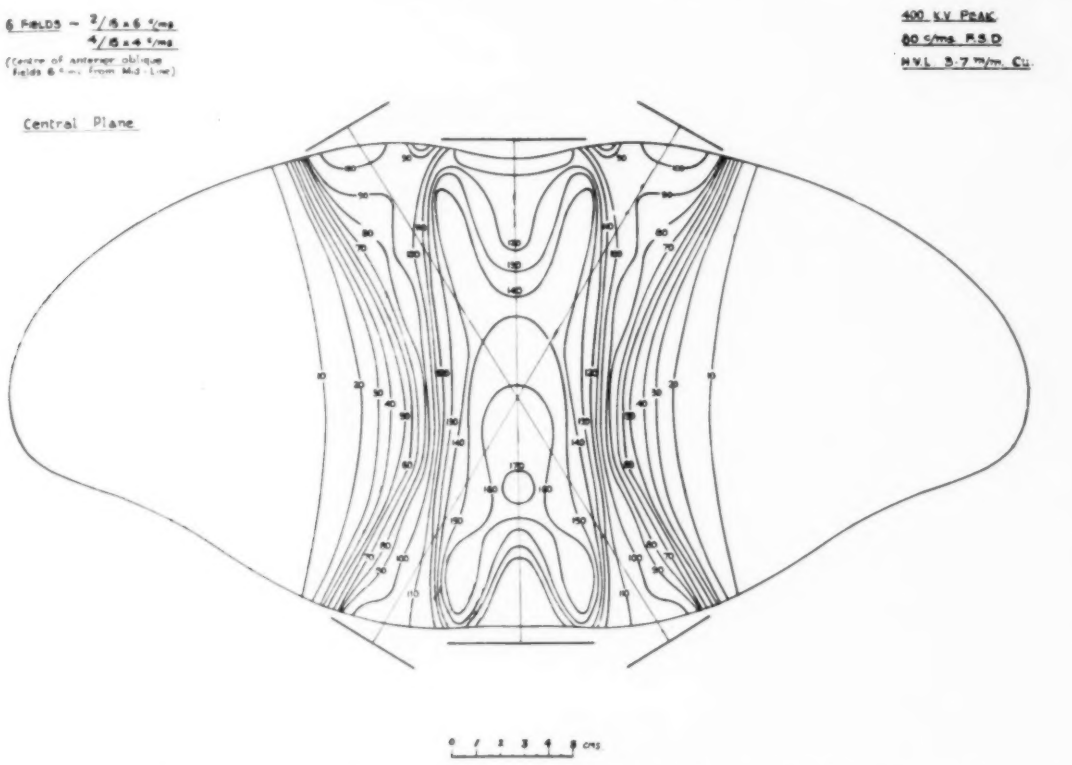


Fig. 5. Central plane distribution as in Figure 4, but with the width of the two central fields increased from 4 cm. to 6 cm.

ods already described by Mayneord.[23] It is found that a 20×4 cm. field (400 kv., peak, 80 cm. focus-skin distance, 3.7 mm. Cu half-value layer) contributes approxi-

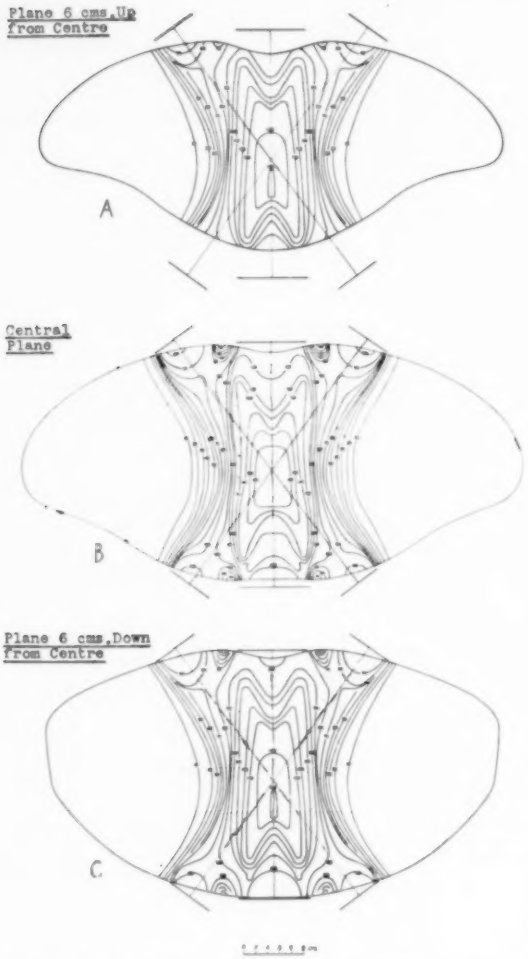


FIG. 6. Distribution in three planes with conditions similar to those shown in Figure 5, but with center of the anterior oblique fields 7 cm. instead of 6 cm. from the midline.

Six fields, two 15×6 cm., four 15×4 cm., 400 kv. (peak), 80 cm. focus-skin distance, 3.7 mm. Cu half-value layer. *A*, plane 6 cm. up from center; *B*, central plane; *C*, plane 6 cm. down from center.

mately 1,100 gram-roentgens per roentgen on the surface, a 15×6 cm. field 1,310 and a 15×4 cm. field only 770 gm-r each for total absorption. The six 20×4 cm. fields therefore give in all 6,600 gm-r per roentgen as opposed to 5,700 gm-r for the four 15×4 cm. plus two 15×6 cm. fields. In the "average patient" a minimum tumor dose of 6,000 r with the 20×4 cm. fields gives an "integral dose" of 28 megagram-roentgens, and with the 15×4 and 15×6 cm. fields 24 megagram-roentgens.

3. *Localization, fixation and beam direction.* The first step when the diagnosis is confirmed and the patient well enough for treatment is to localize the tumor. For this purpose we have adopted the method described by Roberts.[28] The tumor is localized by aligning it between two points on the surface in several planes using the fluoroscopic screen. The tumor is located by barium in the esophagus and the skin marked by a lead cross on one side of the chest and a lead ring on the other. The anteroposterior positions are marked first, the anterior lead ring is then moved 7 cm. to one side and the position for the corresponding posterior oblique field found, and then 7 cm. to the other side and the process repeated. Two details are of importance: first, the beam of roentgen rays must be horizontal, and second, the shutter must be closed down to a small aperture so that only the narrow central beam is used and distortion avoided. The six points are then marked on the skin. The disadvantage of skin markings is that their position relative to the tumor may change with position of the patient. In the present case this is particularly likely to occur when marks are placed on the skin over the vertebral borders of the scapulae. It is therefore important to screen the patient in that position in which he will be treated, preferably on the treatment couch itself. As the barium outlines the upper limit of the obstruction it is a point towards the upper end of the tumor that is localized. The fields are therefore applied so that one-third of their length extends above this level and two-thirds below. The points of entrance and exit of the central ray of each beam falls 2.5 cm. below the skin marks. An attempt is made to outline the lower limit of the tumor (Fig. 10) but this is not regarded as giving a very accurate indication of its extent.

A cross-section drawing of the patient's chest is then made. Metal strips molded around the chest do not give a sufficiently accurate outline so a special apparatus was designed by Professor W. V. Mayneord for this purpose. This apparatus (Fig. 7) is similar to one previously described by Martin.[20] It consists of a rectangular metal frame hinged at the center of one short side and joined by a catch at the center of the opposite side. This frame carries a number of small metal rods which pass through it horizontally on all four sides. The frame can be opened, placed around the patient at the required level, and closed again. The metal rods are then pushed inwards until they just touch the skin around the whole chest surface. The catch is released and the frame opened and removed. The frame is now closed again and placed over a drawing board so that the outline of the chest at that level can be transferred to paper.

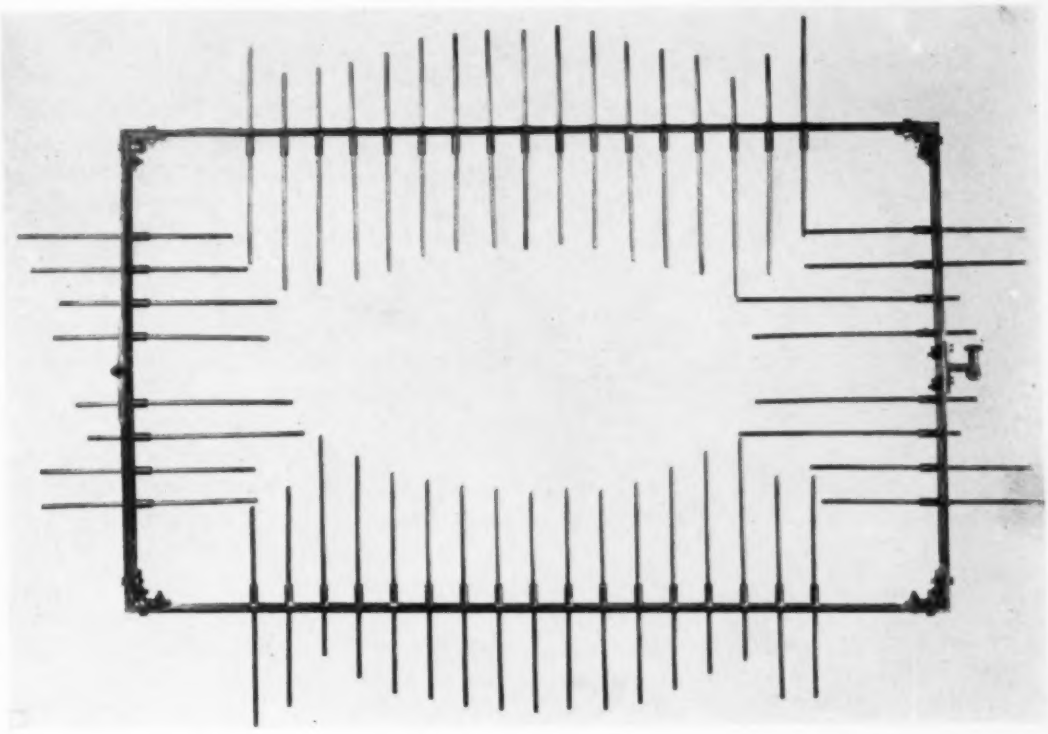


Fig. 7. Apparatus used to obtain a cross section drawing of the chest at any level.

The position of the skin marks are placed on the cross-section drawing, and joined by lines representing the central axes of the beams of radiation. If the procedure has been carried out accurately, the three lines should all intersect at one point, the center of the tumor. This is the first check on accuracy. The distance between the points of entrance and exit of each beam is measured on the patient with calipers and checked on the drawing. A lateral roentgenogram of the chest is taken with barium in the esophagus at a distance of 6 feet and the position of the tumor in an anteroposterior direction found. This is again checked with the position of intersection of the lines on the drawing. This cross-section is then used to determine the tumor dose due to a combination of the six fields selected in this particular patient.

In order to ensure accurate beam direction the patient is treated in the sitting position. Slight degrees of rotation of the patient may pass unnoticed if he is lying

down. If the patient is to be treated sitting up he must be fixed rigidly and yet supported in comfort. I have designed a roentgen therapy couch intended for use with patients having treatment to any part of the body. It is a modification of the "Panapoise" treatment table made by the Medical Supply Association. When the thorax is to be irradiated, axillary crutch supports and a webbing band are attached on either side and can be adjusted inde-

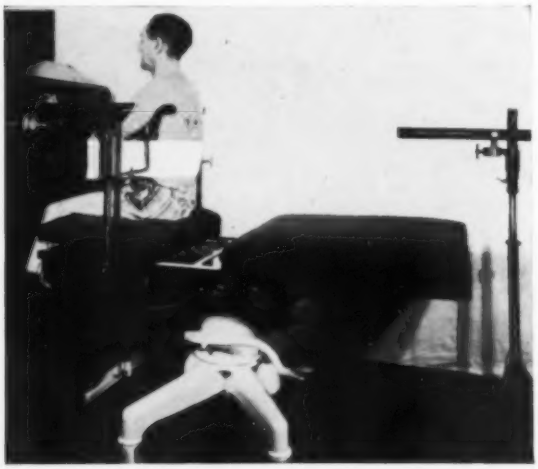


FIG. 8. Patient in position for treatment to the central anterior field, showing collineator and treatment couch.

pendently (Fig. 8). The axillary supports prevent lateral movement and a slight tilt of the seat prevents the patient slipping forwards. The webbing band passes round the patient above or below the skin marks and gives added support without interfering with free access to the whole thorax.

The accurate direction of the roentgen-ray beam is realized by the use of Mayneord's collineator.[21] When the patient is placed in position (Fig. 8) so that the hole in the center of the applicator falls 2.5 cm. below one skin mark and is then rotated until the beam of light from the collineator falls 2.5 cm. below the opposing mark, the conditions that pertained when the marks were fixed at screen examination are reproduced. The collineator lamp is operated by a switch in the control room so that it can be turned on frequently during treatment to see that the position has been maintained.

4. *Scheme of irradiation.* It is not possible to go through the lengthy process of determining the complete volume distribution of the radiation in every case. The main function of volume distributions is to determine the best standard arrangement of fields for a particular group of cases. Having decided this, it is then only necessary to determine the maximum and minimum tumor dose as accurately as possible for each case. For this purpose the cross-section diagram already referred to is used. The central plane isodose curves (Fig. 21) are placed in position on this chart for each field and the dose at the point of intersection of the central rays calculated. This represents the maximum tumor dose. It is not possible to determine the minimum tumor dose with the same degree of accuracy as the exact extent of the tumor is not known. From the volume distribution charts it can be seen that the central high dose region extends along the length of the esophagus sufficiently to include all probable local spread. The dose falls off laterally on either side of the central point more rapidly than it does in an anteroposterior direction so that the minimum tumor dose will occur in this region. We have selected an arbitrary point situated 2 cm. laterally from the tumor center and the dose is determined at this point also in every case. This dose is stated as the minimum tumor dose in the present series. It indicates that the dose to the tumor is greater than this at every point provided that the tumor is not more than 4 cm. broad at its center and falls within the isodose surface receiving this dose in the planes above and below the central plane. We believe this to be an adequate representation of the minimum tumor dose in the great majority of cases and to represent an under-statement in some instances.

A treatment is given to all six fields each day. All fields are irradiated daily so that not only is an even total tumor dose given but also an even daily tumor dose. The

treatment is given each week day over a period of five to seven weeks. Daily fractional treatment over a period of approximately six weeks has been adopted in the present state of our knowledge as being that which offers the best chance of success. It is to be hoped that we may later arrive at a stage when we can select the appropriate spacing of our fractional irradiation according to the histological structure of the tumor. Thus we may hope to obtain the maximum tumor effect in every case. Daily irradiation has been adopted for the present with the dose given each day remaining constant or rising towards the end of treatment in the case of the more highly differentiated tumors.

The majority of the cases in the present series have been treated with a Victor (400 kv., peak) "Maximar." The filtration was 0.22 mm. Sn with 1.7 mm. Al added, the inherent filtration being equivalent to 2.0 mm. Cu, the half-value layer of the radiation being 3.7 mm. Cu. The focal skin distance was 80 cm. The dosage rate on the skin surface was about 10 r/min. and at the tumor center about 3 r/min. The daily dose to each field is so arranged that if treatment is uninterrupted the tumor dose will be between 6,000 and 7,000 r in six weeks. In the average case this means a daily dose per field of 100 r. Any air spaces between portions of the applicator and the chest wall are filled in with rice bags. Each treatment is plotted on a graph showing the variation of dose with time and plotted daily (see upper part Fig. 1). These graphs show the maximum and minimum tumor dose given and the shape of the curve of dose with time.

5. *Care of the patient after treatment.* Within a week or two of the cessation of treatment the barium filled esophagus is examined on the screen and a roentgenogram taken for comparison with the original and subsequent films. This examination is repeated six to eight weeks later. By this time the reaction has subsided in most cases and an esophagoscopy may be performed. In a successful case the first esophagoscopy following treatment may show some edema and small areas of flat ulceration but later examinations show only a thin white scar. Thick scars forming obstruction are not seen but some general contraction may take place. If there is the least tendency to this fibrotic constriction careful and repeated dilatation should be undertaken. The higher the tumor in the esophagus, the more frequently does dilatation appear to be required. An esophagoscopy is performed every few months or at any time that untoward symptoms appear. A portion of any suspicious area may be taken for biopsy at any of these examinations. A roentgen examination is carried out from time to time as a check and the patients are weighed regularly.

Postcricoid Tumors of the Pharynx and Tumors of the Cervical Esophagus.

The points referred to in the description of the treatment of tumors of the thoracic esophagus apply also to tumors of the upper and lower limits of the organ with the exception of the arrangement of the fields. Tumors of the upper limit of the esophagus lie nearer the anterior than the posterior surface at a level where the thorax is flattened anteroposteriorly. Tumors in this region do not tend to spread so rapidly or so extensively along the length of the esophagus as do those arising at a lower level. It is not, therefore, necessary to use as many as six fields or to employ long strips. Four small strip fields 10×6 cm. may be used on either side of the midline, two in front and two behind, the posterior fields being further from the midline than the anterior, as the tumor is nearer the front than the back. This gives a good distribution so far as the primary tumor is concerned but owing to the curvature of the base of the neck it is difficult to set these fields accurately or closely in contact with the skin. For this reason and also because it includes the lymph nodes at the base of the neck we have adopted the following arrangement.

A directly opposing anteroposterior pair of fields measuring 10×6 cm. is arranged

so that the two central rays pass through the tumor. Two 7 cm. diameter circular fields are placed on either side of the neck in the same anteroposterior plane as the tumor but angled downwards and inwards. The central rays of these two beams meet at a point just below the tumor so that the region of high dosage due to them falls at the tumor level. The distribution is worked out for each individual case as they vary widely. For this purpose a plaster mask is made of the patient's neck and shoulder regions and the dose from the four fields determined on an improved form of Mayneord's "dose finder."[22] The position of the fields is finally fixed on the mask and the angle on the tube adjusted so as to reproduce this position on the patient. The anteroposterior fields are aligned with the collineator as before.

Tumors of the Abdominal Esophagus and of the Cardiac End of the Stomach Involving the Esophagus.

As already stated, the main difficulty in giving an adequate dose of roentgen rays to a carcinoma of the esophagus is the constitutional effects produced, especially the leukopenia. With tumors in the region of the cardia this difficulty is increased as both the liver and spleen will be irradiated. As a result, an adequate tumor dose has seldom been given in the past and the results have been so disappointing that the method has practically been abandoned for tumors in this situation. Regelsberger[27] succeeded in getting relief of symptoms, gain in weight and disappearance of occult blood in the stools in 60 per cent of cases of inoperable gastric cancer. Of 35 patients treated by him 6 survived more than a year and 2 of them were still alive three years after treatment at the time of his report. Merritt[24] treated 13 patients and 3 were alive, well, and symptom free at the time of his report. Patients with tumors in this region are sometimes treated by the implantation of radon seeds with marked tumor regression and relief of symptoms. There is no doubt that many of these tumors are moderately radiosensitive. We have therefore recently attempted to treat with roentgen rays a few patients with gastric carcinomata situated at the cardia and involving the esophagus.

Tumors at the lower limit of the esophagus are to the left of the midline and form a more rounded tumor mass than those in the thoracic esophagus. The arrangement of fields used has either been four fields 10×10 cm. in two directly opposing pairs or more recently six fields measuring 10×6 cm. in three pairs. The treatment was carried out in the same way as for the thoracic tumors and, although it was not often possible to give so high a dose, a minimum tumor dose of 5,000 r in six weeks was reached in several cases.

Account of the Cases of Carcinoma of the Esophagus Seen at the Royal Cancer Hospital from 1936 to 1939.

This report is concerned chiefly with 66 patients referred to the roentgen department but in order to indicate how far these represent a selected group the hospital records were examined and a further 49 cases found. Table VI shows the distribution of these cases according to site of the tumor.

Eight of the 10 cases of postcricoid carcinoma not referred to the roentgen department received teleradium treatment. Ten of the remaining patients not referred for roentgen treatment were treated with a radium bougie and 9 with radon seeds, 3 were operated on and 19 had no treatment or merely a palliative gastrostomy. Of the 66 patients referred to the roentgen department treatment was attempted in 54 and completed in 40. The distribution of these patients according to the site of the tumor and the immediate response to treatment is given in Table VII.

Only 4 patients who completed their treatment noticed no improvement; all had tumors in the middle of the esophagus. Three patients received partial relief of symptoms without completing their treatment, 1 had a tumor in the middle third and 2 in the lower third of the esophagus.

TABLE VI

DISTRIBUTION OF ALL 1936–1939 CASES ACCORDING TO THE SITE OF THE TUMOR

	Postcricoid Tumors of Pharynx	Tumors of Esophagus			Tumors of Stomach Involving the Esophagus	Total
		Upper Third	Middle Third	Lower Third		
Not referred to roentgen department	10	4	16	6	13	49
Referred to roentgen department	4	8	34	9	11	66
Total	14	12	50	15	24	115
Male	2	10	36	12	21	81
Female	12	2	14	3	3	34

Three patients had already received some roentgen treatment elsewhere, 1 was too ill to treat at all, 1 had two weeks' treatment and died one week later, the third had only had a very small dose one month before and completed treatment with some relief of symptoms. No patient was said to have had a partial relief of symptoms unless his swallowing definitely improved and he gained weight. With the exception of cases of carcinoma of the stomach no patient was considered to have completed treatment who did not receive a minimum tumor dose of at least 5,000 r. For those who completed treatment the shortest treatment period was thirty-five days and the longest 118 days, the great majority were treated in from forty to fifty days.

Of the 12 cases that were not treated, 3 were lost sight of, the remaining 9 lived an average of 2.6 months. Of the 14 that did not complete treatment, 2 were lost sight of, the remainder lived an average of 2.5 months.

Results of Treatment.

1. *Postcricoid tumors.* The majority of cases of postcricoid carcinoma were referred to the radium department and treated with teleradium. Of the 4 cases treated by roentgen rays 2 already had cervical lymph node involvement and 1 had started teleradium treatment when war was declared and was then transferred to the roentgen department. This last patient had nearly two-thirds of her treatment by teleradium;

TABLE VII

CASES REFERRED FOR ROENTGEN TREATMENT 1936–1939

	Postcricoid Tumors of Pharynx	Tumors of Esophagus			Tumors of Stomach Involving the Esophagus	Total
		Upper Third	Middle Third	Lower Third		
Total	4	8	34	9	11	66
Male	0	6	25	8	11	50
Female	4	2	9	1	0	16
Treated	4	8	28	8	6	54
Completed treatment	3	5	21	6	5	40
Average duration of symptoms before admission in months	4.2	4.3	4.2	3.5	8.5	
Symptoms not relieved	1	3	9	2	0	15
Symptoms partially relieved	1	1	12	5	4	23
Symptom free	2	4	7	1	2	16

TABLE VIII

RESULTS OF TREATMENT IN CASES OF CARCINOMA OF THE STOMACH INVOLVING THE ESOPHAGUS

Age	Length of Symptoms before Admission in Months	Time between Treatment and Death in Months	Treatment Given (Tumor dose)	Subsequent History
60	9	6	2,000 r in 23 days	Died at home
60	12	8	5,500–5,100 r in 40 days	Marked improvement followed by return of symptoms increasing weakness and death
64	4	4	5,800–5,300 r in 39 days	Slight improvement in symptoms. Died with metastases
69	2	3	5,800–4,900 r in 46 days	Slight improvement in symptoms. Died
50	12	Alive	5,300–4,700 r in 44 days	Alive and symptom free 1 year and 2 months after treatment
51	12	Alive	5,500–4,300 r in 47 days	Alive 1 year after treatment with some difficulty in swallowing solids

when last seen fifteen months after treatment she was symptom free with no sign of any recurrence. Of the 2 patients with cervical lymph node metastases 1 had to have a gastrostomy, failed to complete her treatment owing to weak condition and dyspnea, and has not been heard of since; the other completed treatment. In this patient the hard lymph nodes palpable on both sides of the neck subsided and swallowing was much improved; she was alive and well when last seen six months after treatment but had required occasional dilatation. The 1 patient with no palpable lymph nodes treated solely by roentgen irradiation was sent by Mr. R. Scott Stevenson and discussed by him at the Section of Laryngology of the Royal Society of Medicine previously.[30] It was not possible to obtain a piece of the tumor for biopsy to confirm the diagnosis histologically in this case. The patient aged seventy-six lived for seventeen months free from symptoms and died of intercurrent disease without any sign of recurrence.

2. *Tumors of the stomach involving the*

TABLE IX

RESULTS OF ROENTGEN TREATMENT OF 32 PATIENTS WITH CARCINOMA OF THE ESOPHAGUS

	Upper Third	Middle Third	Lower Third	Total
No. of cases	5	21	6	32
No. dead	2	19	5	26
Average time from onset of symptoms to death in months	9	13.2	13.8	12.9
Average time from treatment to death in months	5.5	8.5	12.5	8.5
No. alive	3	2	1	6

TABLE X

DETAILS OF THE 6 PATIENTS STILL LIVING FOLLOWING ROENTGEN TREATMENT FOR CARCINOMA OF THE ESOPHAGUS

No.	Sex	Age at Beginning of Treatment	Pathological Report	Position of Tumor	Tumor Dose	Survival Period from Onset of Symptoms Till Last Seen, in Months	Survival Period from Treatment Till Last Seen, in Months	Condition of Patient When Last Seen
1	M	56	Grade 1 fungating squamous cell carcinoma	Upper third	7,200 r in 118 days	50	48	Symptom free
2	F	64	None	Middle third	6,900–6,300 r in 39 days	37	32	Has attacks of dysphagia at times. Was never dilated
3	M	64	Grade 4 squamous cell carcinoma (basal cell type)	Lower third	6,900–6,500 r in 41 days	32	27	No difficulty in swallowing. Admitted to another hospital and getting weaker
4	M	61	Grade 2 intra-epithelial squamous cell carcinoma	Upper third	6,400–5,800 r in 39 days	32	29	Symptom free
5	F	75	Grade 2 squamous cell carcinoma	Upper third	5,500–5,200 r in 30 days	16	13	Not seen since April, 1940. Was then symptom free and had no sign of growth on esophagoscopy
6	F	74	Grade 2 squamous cell carcinoma	Middle third	6,400–5,300 r in 43 days	15	14	Symptom free

Average length of symptoms before treatment 3.2 months. All showed more or less widespread invasion of submucous tissue. Submucous lymphatic invasion seen in Cases 4 and 6. Cases 1, 4 and 6 have had a recent esophagoscopy performed without any sign of a tumor being observed.

esophagus. Six patients were treated in this group, 1 failed to complete treatment, 1 is still alive but has had a return of symptoms, and 1 is alive and symptom free. This last patient showed no sign of growth when given a barium meal or esophagoscoped. The results of treatment in this group are shown in Table VIII.

3. *Tumors of the esophagus*. Fifty-one patients with carcinoma of the esophagus were referred for roentgen treatment, 44 were treated and 32 completed their treat-

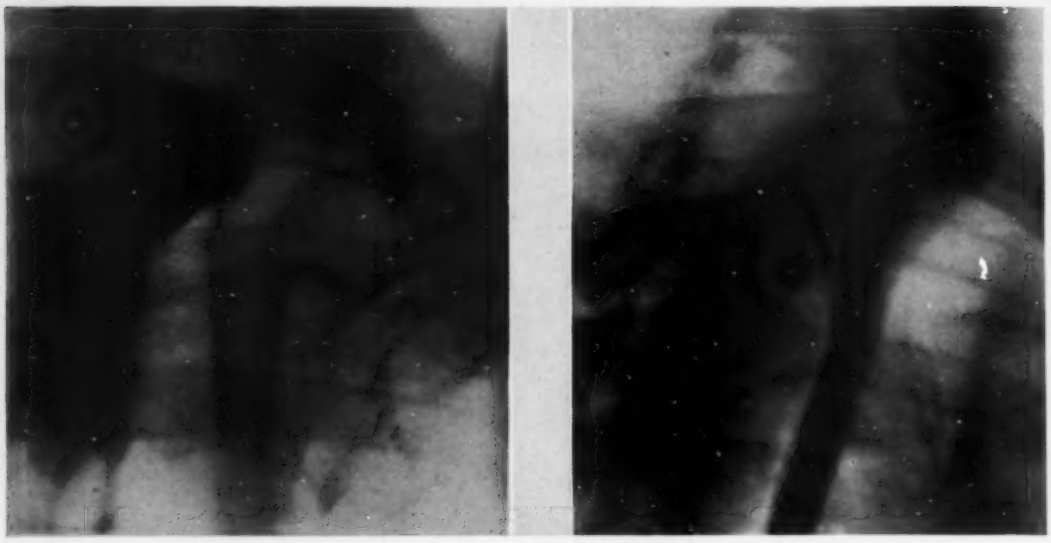


FIG. 9. Carcinoma of the upper third of the esophagus before treatment and six months after treatment (Case 4, Table x).

ment. These 32 were divided into 5 with the main part of the tumor in the upper third of the esophagus, 21 in the middle third, and 6 in the lower third. The results of treatment are shown in Tables IX and X.

Eight of the patients who died lived a year or more after treatment and 1 lived more than two years. Three who died with metastases were known to have had no return of symptoms, and 4 others who were never symptom free could swallow semi-solids to time of death; in 2 of these an

FIG. 10. Carcinoma of the middle third of the esophagus before and after treatment. Patient swallowed normally until she died one year and two months later with metastases.

esophagoscopy performed shortly before death showed no evidence of local growth. Of the 25 patients in this group who died, 10 were known to have developed metastases, 3 were known to have died following perforation, and in 13 the only information received was the date of death.

Figures 9-12 show roentgenograms of some of these patients before and after treatment. Figure 13 shows the roentgenograms and postmortem specimen of another case of considerable interest. Despite the length of esophagus irradiated, extension took place at the level of the upper and lower limits of the treatment fields.

From these tables it can be seen that 1 patient is alive and well four years after treatment. This patient was treated by Dr. S. B. Nowell who was at that time working in the roentgen department of the Royal Cancer Hospital. Three other patients are alive and well more than two years after treatment. One has gained as much as two stone in weight.

Figure 14 shows the effect of treatment

Fig. 11. Carcinoma of the middle third of the esophagus before treatment and three months after treatment (1940 case).

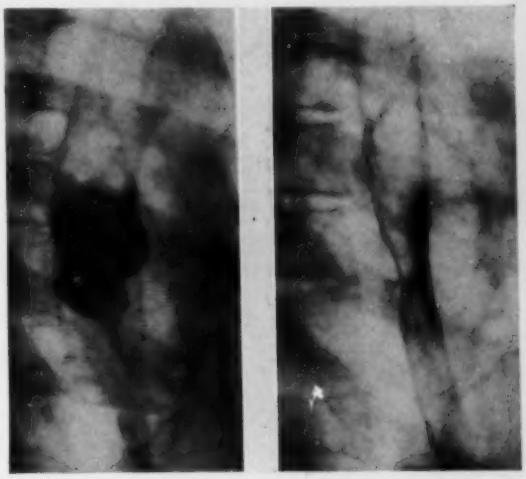


Fig. 12. Carcinoma of the lower third of the esophagus before treatment and eight months after treatment (Case 3, Table x).

in the whole group of 32 patients. Of 44 patients treated 30 obtained some relief of symptoms and 11 complete relief. Of 15 patients treated during the first half of 1940, 7 have obtained some relief and 7 are symptom free.

There has been no case which has developed fibrosis of the lungs. Skin reactions, with the exception of one or two of the early cases, have been mild erythemas only. There has been no sign of cardiac damage in any of the patients treated. In only 1 case was there any damage to normal tissues which might be attributed to the effect of the roentgen irradiation. This patient (Case 4 in Table x) developed a lesion in his spinal cord one year and three months after treatment. He was examined by Dr. C. Worster-Drought who made the following commentary: "The neurological syndrome found is one of Brown-Séquard syndrome and results from a unilateral lesion in the left side of the spinal cord at the level of the third and fourth thoracic segment. The lesion is intramedullary and there is no block in the spinal subarachnoid canal. The lesion can only be one of intramedullary gliosis, i.e., spinal gliosis which may or may not be an early stage of syringomyelia." The cerebrospinal fluid was normal and the Wassermann reaction negative. The level

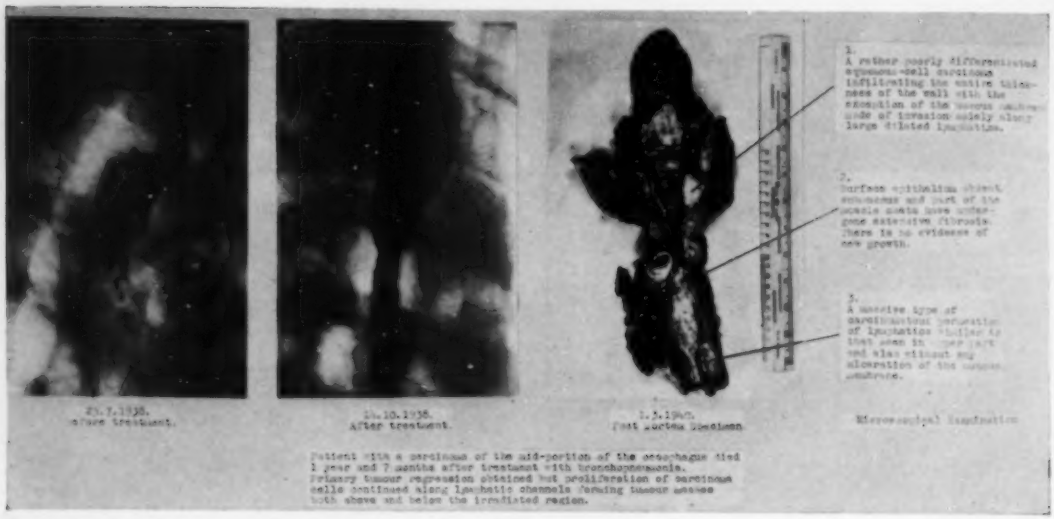


FIG. 13. Carcinoma of the middle third of the esophagus showing eradication of tumor at the site of obstruction and submucous extension of the growth above and below the level of the treatment fields.

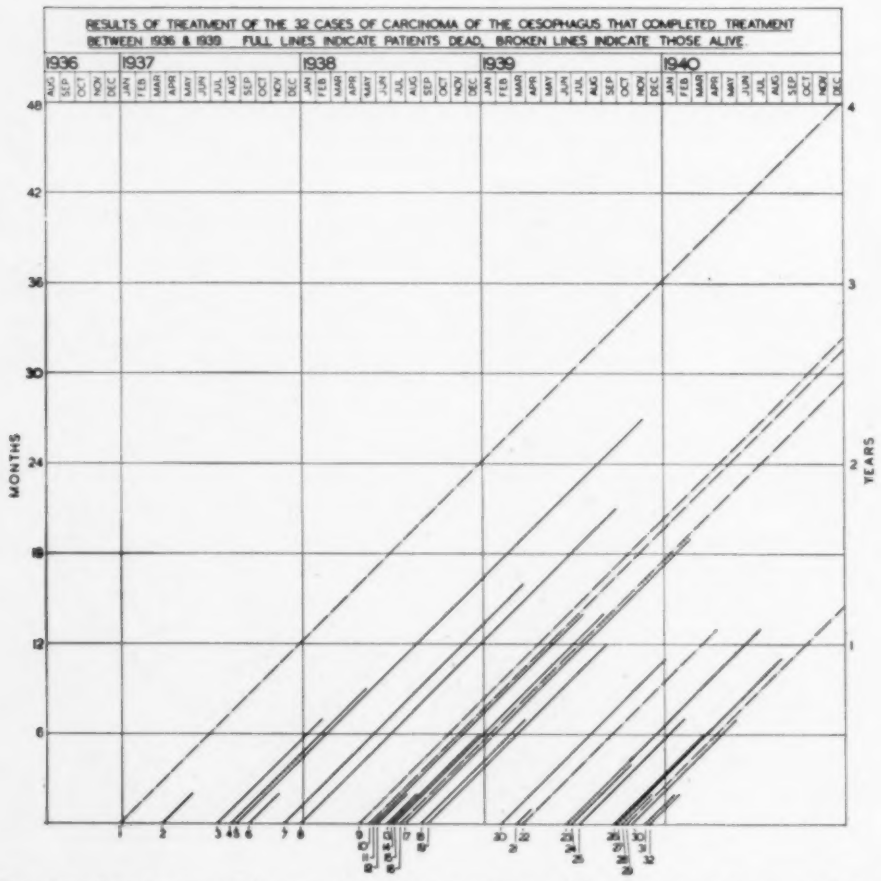

RESULTS OF TREATMENT OF THE 32 CASES OF CARCINOMA OF THE OESOPHAGUS THAT COMPLETED TREATMENT BETWEEN 1936 & 1939 FULL LINES INDICATE PATIENTS DEAD, BROKEN LINES INDICATE THOSE ALIVE
1936
1937
1938
1939
1940
MONTHS
YEARS

FIG. 14. Results of treatment in those patients who received a full tumor dose between 1936 and 1939.

of the lesion was in the previously irradiated region and it was calculated that the spinal cord at this point received a dose of 5,800 r in thirty-nine days.

The final modifications of the treatment techniques described were put into full operation at the beginning of 1940. Table XI gives the details of the 20 patients in this group who have been seen during the first six months of the year. It is too soon to comment on anything but the immediate symptomatic response in these cases. The fact that only one failed to complete treatment and that this was the only one who obtained no relief of symptoms is an encouraging sign. This patient died in one month with metastases in the liver. Of the 5 patients who were not treated, 3 are known to have died in less than one month and the other 2 had metastases when first seen. In 1 case there was a large fixed mass of cervical lymph nodes and in the other multiple secondary deposits were visible in a chest roentgenogram.

This paper was completed in December, 1940, but owing to war conditions was not despatched for publication until April, 1941. At the time of correcting the proofs (March, 1943) Cases 1, 2 and 4 in Table X were still alive and symptom free at six years and three months, five years, and four years and eight months from treatment. Case 3 died two years and four months after treatment with metastasis but no sign of local recurrence. Case 5 died eighteen months after treatment from intercurrent disease without any return of symptoms. Case 6 died eighteen months after treatment with metastasis and return of dysphagia.

TABLE XI

CASES REFERRED FOR ROENTGEN TREATMENT DURING THE FIRST SIX MONTHS OF 1940

	Postcricoid Tumors of the Pharynx	Tumors of the Esophagus			Tumors of the Stomach Involving the Esophagus	Total
		Upper third	Middle third	Lower third		
Total	3	2	5	5	5	20
Male	0	2	5	4	4	15
Female	3	0	0	1	1	5
Treated	2	2	3	4	4	15
Completed treatment	2	2	3	4	3	14
Average duration of symptoms before admission in months	8	2	2.8	4.4	6.4	
No relief of symptoms	0	0	0	0	1	1
Symptoms partially relieved	2	0	1	4	0	7
Symptom free	0	2	2	0	3	7

PART II

AN ACCOUNT OF THE PHYSICAL MEASUREMENT OF THE VOLUME ROENTGEN-RAY DOSAGE DISTRIBUTION DUE TO ELONGATED FIELDS

By J. R. Clarkson and J. A. Strong

Introduction. The study of the distribution of dosage throughout the irradiated volume in certain selected methods of roentgen or gamma-ray therapy has lately been undertaken at the Royal Cancer Hospital (Free) and results have already been published.[14] The methods described are applicable to fields having an axis of symmetry and require that a three-dimensional isodose surface system may be constructed by rotation of the normal plane diagram about that axis. In the present case where the treatment is carried out by the use of elongated rectangular fields these methods

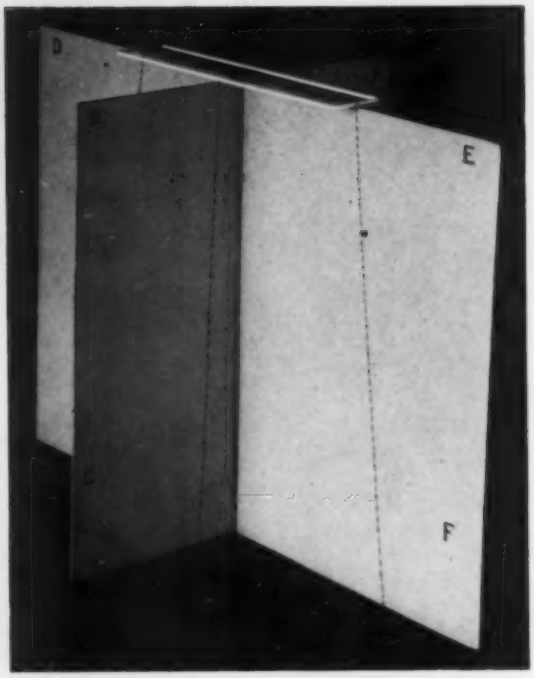


FIG. 15. Position of the reference planes with respect to the 20×4 cm. applicator.

are not applicable. The method of investigation adopted was to make dosage measurements throughout the whole volume irradiated by such a field and to construct dose contour diagrams in planes normal to the surface, afterwards combining the results for each of the six fields in the appropriate positions to obtain a diagram of the complete dose distribution at certain planes in the body.

In Figure 15, the outline of the applicator 20 cm. long and 4 cm. wide is represented by a rectangle lying on top of the cardboard sheets *ABC* and *DEF*. The dotted lines represent the geometrical limits of the irradiated volume in these planes. The plane *ABC* at right angles to the surface of the applicator and parallel to the shorter axis of the field is called the central plane. The plane *DEF* is called the longitudinal plane. Dose contours were constructed for the central plane and for planes parallel to it, but distant 5, 8, 10, 11 and 12 cm. from it on either side. The measurements of dosage were made in a water phantom of dimensions 43.5×42.5×110 cm.

Apparatus and Measurement Technique. The treatment of carcinoma of the esophagus is carried out at the Royal Cancer Hospital (Free) with a tube excited by 400 kv. pulsating tension, found with the filters used (0.22 mm. Sn+2 mm. Cu+1.7 mm. Al) to be equivalent to 350 kv. constant potential. The results described here were obtained in the physics department using this constant potential and filter. The half-value layer of the radiation was found to be 3.7 mm. Cu, identical with that of the radiation used in the treatment.

The cylindrical ionization chamber employed was of 5 mm. internal diameter and 5 mm. internal length made of "Aerion." This, and the measuring system have been previously described,[8] but certain modifications were introduced to permit of movement of the chamber in three directions. A further section of "Tombac" tubing was introduced into the evacuated conduit carrying the connection to the chamber electrode and also a fulcrum to provide a fixed point approximately 4 meters from the chamber about which the latter could move. The fulcrum consisted of a square aperture in a brass plate, allowing the lead to slide fairly freely but not permitting lateral or vertical movement at that point. As previously described, the lead was supported near its center in a block movable in two directions and lateral or vertical movement of the point of support could be read from vernier scales while longitudinal movement was read on a scale attached to the lead and moving past an edge on the support. With this arrangement when the point of support was moved laterally or vertically, the chamber moved in circular arcs about the fulcrum as center, while longitudinal movement by sliding the connecting lead was necessarily accompanied by a slight change in level except in the special case where the point of support was in the same horizontal line as the fulcrum. Before commencing measurements of depth dosage the rectangular coordinates of the

center of the chamber were determined for a range of positions of the three scales, using squared paper set accurately horizontally or vertically and wire pointers on the movable lead. By graphical interpolation the precise position of the chamber in the field was known for any setting of the scales. By the use of cross threads mounted on the limiting diaphragm of the beam and immediately above the surface position of the chamber in the phantom, and also a marker on the bottom of the water phantom, the tube focus, center of field at surface, and center of chamber were put accurately into vertical alignment. The field was limited to 20×4 cm. by an aperture in a lead diaphragm distant 55 cm. from the focus, the total focal distance to the water surface being 80 cm. The aperture size could be adjusted by sliding lead strips approximately 1 cm. thick. Having been set by calculation, the size was checked roentgenographically. The alignment was also periodically checked roentgenographically. In measuring depth doses on the central axis of the field, the longitudinal displacements which resulted as the chamber was lowered were corrected at each step. For other axes the chamber was allowed to move in circular arcs and the position at each setting found from the preliminary measurements of coordinates. The slight rise that accompanied a movement of the chamber on the surface—never more than 2 mm.—was invariably corrected so as to give true surface readings with half the chamber immersed.

Before commencing a set of readings it was confirmed by closing the aperture with lead and attempting a measurement of ionization in the surface position that the stray radiation recorded was negligible. During the early measurements it was found that after a time a serious natural leak developed between the charged outer wall of the chamber and the collecting electrode. This was ascribed to a condensation of moisture on the surface of the amber insulation when the chamber, which had been sealed in a warm and probably humid atmosphere, was lowered into the cold water of the phantom. For the rest of this work the phantom was filled with water a few degrees above atmospheric temperature. The leakage current was then entirely eliminated.

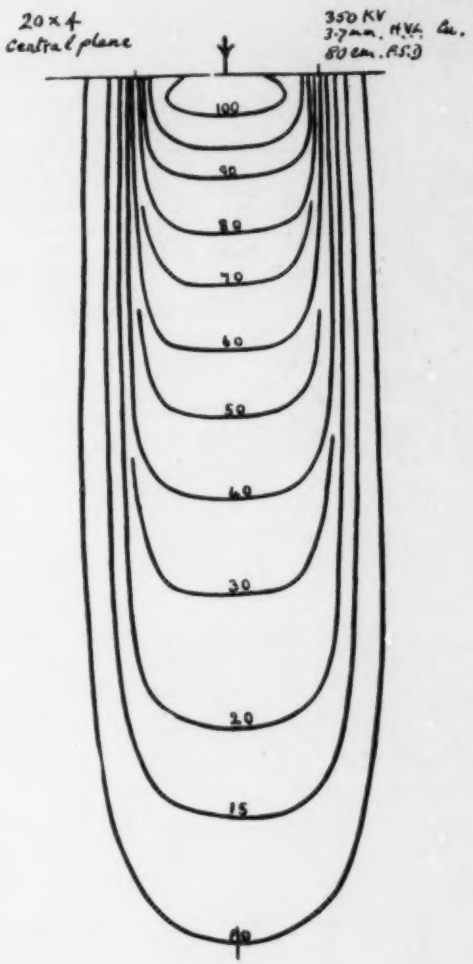


Fig. 16. Dose contours for the central plane.

To enable the constancy of output of the roentgen tube to be maintained a monitoring system was constructed. It consisted of a number of insulated parallel plates of thin aluminum, alternate plates being earthed or maintained at about 2,000 volts potential. This multi-plate chamber was mounted on the tube housing so that the beam passed through it, the relatively large ionization current being passed through a reflecting

galvanometer. In operation, constancy was checked by observation of the galvanometer deflection in preference to reliance on indications of a milliammeter and pre-reading kilovoltmeter.

Method of Constructing Dose Contour Diagrams. Dose contours were obtained for planes parallel to the central plane *ABC* (Fig. 15) and extending to positions outside the geometrical boundaries of the field. The dimensions of a patient and the positions of the fields in treatment were obtained by taking averages of all cases recently treated in the radiological department. The method adopted for the addition of percentage doses in any one plane within the "patient," although somewhat laborious, was thought to give greater accuracy than would have been obtained by estimation and addition using one dose contour diagram successively placed in the positions of the six irradiated fields. The contour diagram of a single field was first drawn on celluloid, and a tracing of it made on paper (Fig. 16). This and the original diagram were placed in the positions of the two central fields, i.e., 21 cm. between surfaces and with axes coincident, and a composite dose contour diagram compiled for these two fields, by drawing on another sheet of paper held firmly over them. The points of intersection of lines on the two original diagrams gave with certainty points on the lines of the composite diagram, and the points were supplemented where necessary by estimation. In the same way a pair of opposing oblique fields were combined and a tracing made for the other pair. By combining in turn the resulting diagrams, the four oblique fields were compounded and lastly the central fields were added (Fig. 2, central plane).

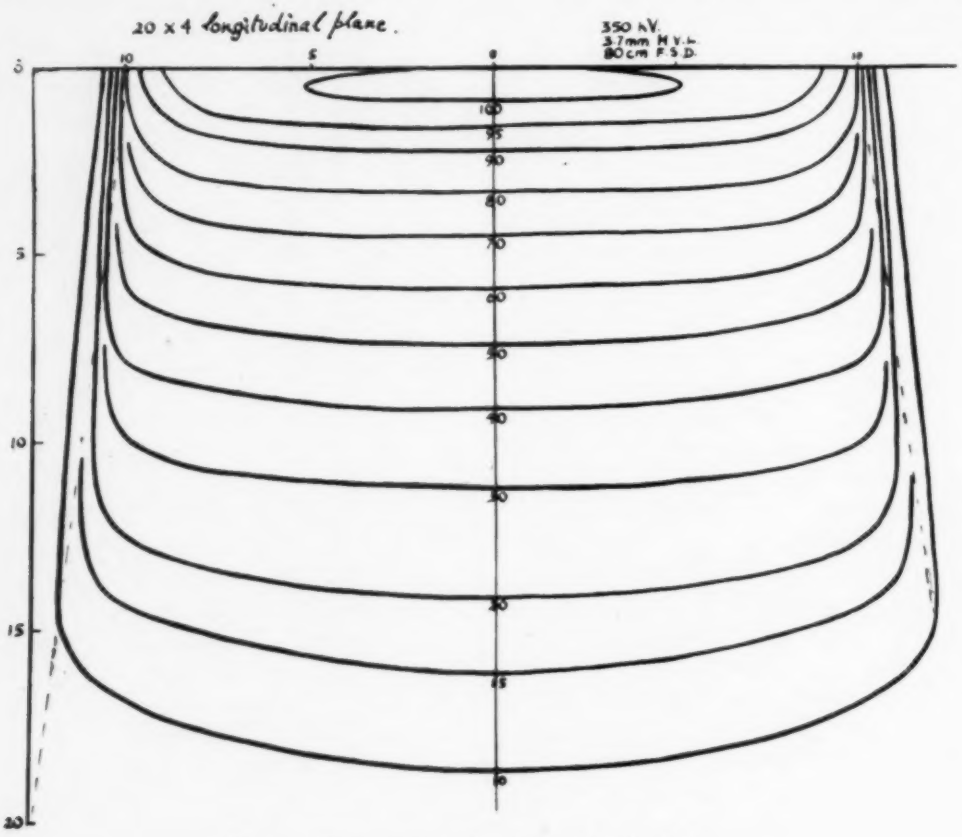


FIG. 17. Dose contours for the longitudinal plane.

Turning now to the isodose diagram for the longitudinal plane (Fig. 17) it will be noted that (1) there is a very small change in depth dose from the central axis to a distance of 8 or more centimeters at average depths; (2) there is a very rapid fall-off in dosage rate outside the geometrical edge of the field. To this and to the necessary widening of the field with depth is due the remarkable appearance of the dose distribu-

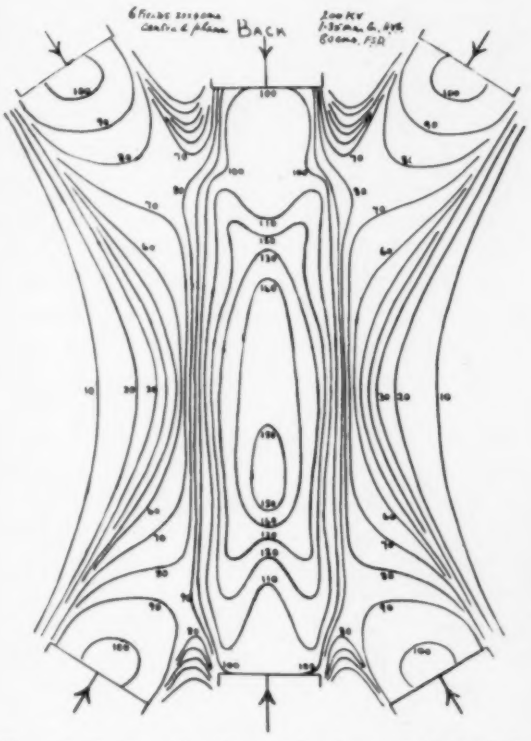


FIG. 18. Dosage distribution in the central plane for six fields each 20×4 cm. in size. 80 cm. focus-skin distance, 200 kv., 1.35 mm. Cu half-value layer (compare with Fig. 2, central plane).

tions in planes at 11 and 12 cm. from the center. Here while the surface dose is negligible, the dose at the center of the diagram is relatively large (Fig. 2, planes 11 and 12 cm. down from center).

Methods of Demonstrating Isodose Surfaces. It is of interest to be able to demonstrate the volume which would receive some definite dose during an average treatment. The model shown in Figure 3 was constructed to show the shape of the 140 per cent isodose surface and the position of the

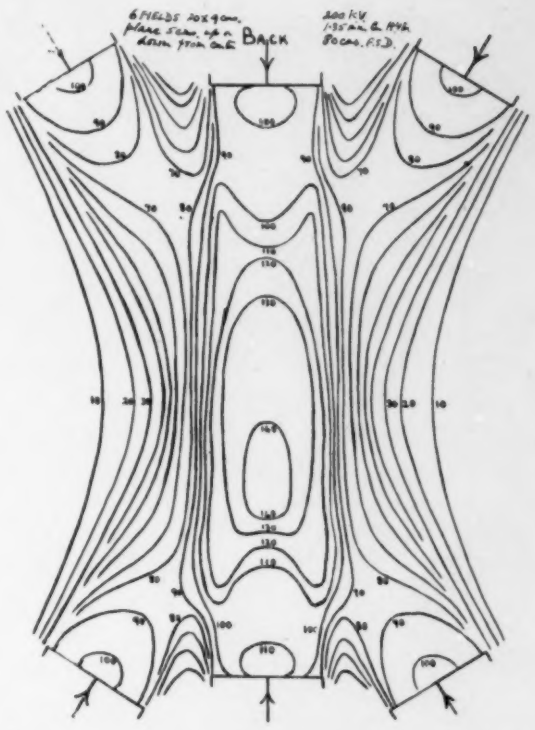


FIG. 19. Distribution in planes 5 cm. above or below that shown in Figure 18. (compare with similar planes, Fig. 2).

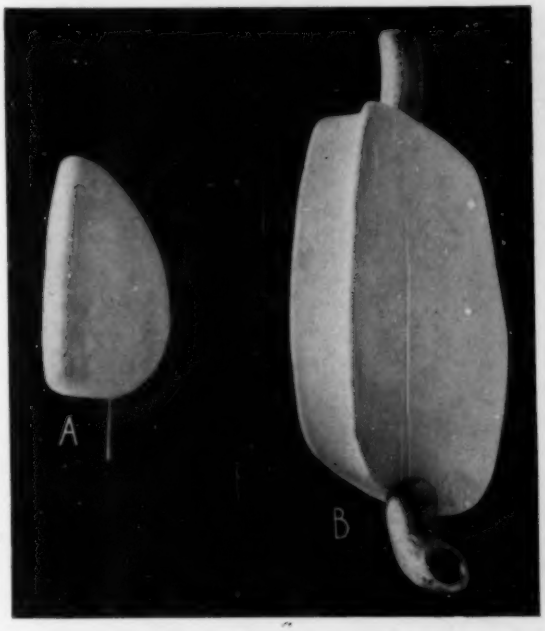


FIG. 20. 140 per cent isodose surfaces *A*, for 200 kv., 1.35 mm. Cu half-value layer, 80 cm. focus-skin distance; *B*, for 400 kv., 3.7 mm. half-value layer, 80 cm. focus-skin distance.

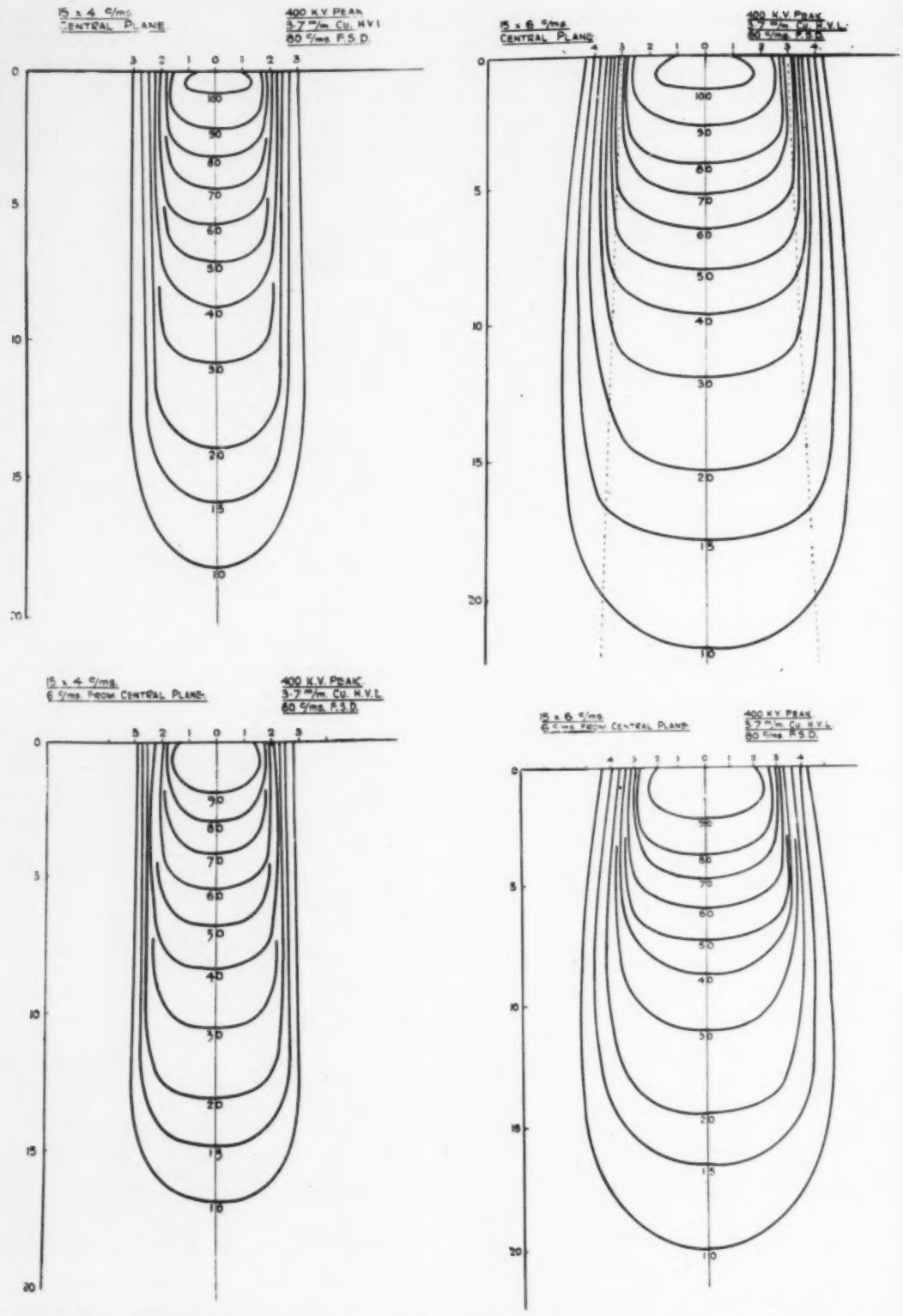


FIG. 21. Dose contours used in determining the tumor dose for each patient as described in Part I.

latter with relation to the outline of the body. The surface was made by fixing cardboard contours of the correct shape at the appropriate distances by separating them with wooden blocks and filling in the volume with plaster of paris.

As it may be desired to obtain dosage distributions in techniques where the strip fields are not applied with their longer dimensions mutually parallel, and where therefore the summation technique described is not applicable, it is useful to be able to use these dose contour diagrams on the dose finder described by Mayneord.[22] This may be done by mounting the diagrams, drawn on a transparent material such as glass or "Perspex," in a metal framework in the correct relative positions. This framework can be supported at the correct angle and position and doses read off with the dose finder. Interpolation will be assisted by making it possible to slide the contour diagrams together at intermediate positions.

As it may be of interest to consider the dosage distributions for a similar technique using radiation excited at 200 kv. having a half-value layer of 1.35 mm. Cu, dosage distributions have been worked out for the horizontal plane through the center of the fields and for a plane 5 cm. from this and parallel to it. These are shown in Figures 18 and 19. As before, a model has been made of the volume enclosed by the 140 per cent dose contour surface. It will be noticed that the surface obtained at 200 kv. is both shorter and narrower than for the more penetrating radiation (Fig. 20) and that the points of maximum dose tend to lie towards the front of the esophagus.

Distributions have also been worked out for a modified technique using four fields of 15 × 4 cm. and two of 15 × 6 cm. in rather different positions from those used with the 20 × 4 cm. fields (Fig. 6). The single-field distributions from which the complete diagrams were obtained are shown in the planes of chief importance in Figure 21.

Conclusion. The measurements made by Quimby, Copeland and Woods[26] in the chest of a cadaver indicate that even for penetrating radiation excited at 700 kv. depth doses are considerably higher than in water. This they ascribe to the air contained in the lungs. While it is realized that the application of physical measurements of dosage made in a homogeneous medium to the complex structure of the human body may be subject to some degree of uncertainty, it is considered likely that the results of Quimby, Copeland and Woods are not applicable to the present case in which narrow fields are arranged so as to avoid to a large extent irradiation of the lung spaces.

Acknowledgment: From the text it will be clear that the treatment of carcinoma of the esophagus by the method described demands the cooperation of the surgeon, pathologist, radiotherapist, physicist and nursing staff. We are greatly indebted to the whole staff of the Royal Cancer Hospital for their assistance. We are especially indebted to Professor W. V. Mayneord, the director of the Physics Department, for his help and advice, and to Dr. J. A. C. Fleming who kindly permitted us to see an, as yet, unpublished paper of his on carcinoma of the esophagus and to quote from it.

REFERENCES

1. Abel, A. L. Treatment of cancer of the esophagus. *Brit. J. Surg.*, 1926, *14*, 131–159.
2. Adams, W. E., and Phemister, D. B. Carcinoma of the lower thoracic esophagus. *J. Thoracic Surg.*, 1938, *7*, 621–632.
3. Baum, S. M. Esophageal-gastric carcinoma successfully treated by protracted fractional x-ray. *Radiology*, 1936, *27*, 58–62.
4. Bendick, A. J. Early esophageal carcinoma. Am. J. Roentgenol. & Rad. Therapy, 1939, *41*, 603–604.
5. Broders, A. C., and Vinson, P. P. Degree of malignancy of carcinoma of esophagus. *Ann. Otolaryng.*, 1928, *8*, 79–80.
6. Buchbinder, W. C. Carcinoma of esophagus with especial reference to site. *Am. J. M. Sc.*, 1925, *170*, 496–499.
7. Carrié, C. Zur Therapie der Röntgenstrahlenleukopenie. *Strahlentherapie*, 1938, *63*, 183–187.
8. Clarkson, J. R., and Mayneord, W. V. "Quality" of high-voltage radiations; "quality" within scattering medium. *Brit. J. Radiol.*, 1939, *12*, 168–180.
9. Clayton, E. S. Carcinoma of oesophagus. *Surg., Gynec. & Obst.*, 1928, *46*, 52–62.
10. Fleming, J. A. C. To be published.
11. Guisez, J. Quelques remarques sur le cancer de l'oesophage. *Presse méd.*, 1937, *45*, 1135–1137.

12. HELSLEY, G. F. Metastazing tendency of esophagus carcinoma. *Ann. Surg.*, 1923, *77*, 272.
13. HILTON, E. L. G. Carcinoma of the esophagus. *Brit. M. J.*, 1937, *1*, 1281.
14. HONEYBURNE, J., LAMERTON, L. F., SMITHERS, D. W., and MAYNEORD, W. F. Symposium on 3-dimensional radiation distributions. *Brit. J. Radiol.*, 1939, *12*, 269–302.
15. IMLER, A. E., and WAMMOCK, H. *Vitamin* B_1 in irradiation sickness. AM. J. ROENTGENOL. & RAD. THERAPY, 1940, *43*, 243–248.
16. LEVITT, W. M. Treatment of carcinoma of esophagus by new method of deep x-ray therapy. *St. Barth. Hosp. Rep.*, 1935, *68*, 107–120.
17. LEVITT, W. M. Faculty of Radiologists: Radiotherapy Section discussion, January 20, 1940.
18. MCGIBBON, J. E. G. Clinical manifestations of spread of carcinoma of oesophagus observed during life. *Brit. J. Surg.*, 1936, *24*, 86–104.
19. MALCOLMSON, G. H., and MALCOLMSON, P. H. Cancer of oesophagus. *Canad. Med. Ass. J.*, 1937, *36*, 405–406.
20. MARTIN, H. E. Device for measuring diameters and the contours of cross-sections of the head and neck. AM. J. ROENTGENOL. & RAD. THERAPY, 1931, *25*, 536–537.
21. MAYNEORD, W. V. Optical device for accurate alignment of x-ray beam. *Brit. J. Radiol.*, 1939, *12*, 257–258.
22. MAYNEORD, W. V. Dose contour projector and application to 3-dimensional radiation distributions. *Brit. J. Radiol.*, 1939, *12*, 262–268.
23. MAYNEORD, W. V. Energy absorption. *Brit. J. Radiol.*, 1940, *13*, 235–247.
24. MERRITT, E. A. Radiation therapy of inoperable intra-abdominal malignancy. AM. J. ROENTGENOL. & RAD. THERAPY, 1936, *36*, 324–331.
25. NIELSEN, J. Klinische Versuche zur Strahlenbehandlung des Speiseröhrenkrebses. *Acta radiol.*, 1940, *21*, 352–367.
26. QUIMBY, E. H., COPELAND, M. M., and WOODS, R. C. Distribution of roentgen rays within the human body. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *32*, 534–551.
27. REGELSBERGER, H. Zur Behandlung des inoperablen Magenkarzinoms. *Strahlentherapie*, 1938, *61*, 201–232.
28. ROBERTS, F. Malignant disease of oesophagus. *Brit. J. Radiol.*, 1936, *9*, 732–742.
29. SOUTTAR, H. S. Treatment of carcinoma of the oesophagus. *Brit. J. Surg.*, 1926, *14*, 131–159.
30. STEVENSON, R. S. Early post-cricoid carcinoma. *Proc. Roy. Soc. Med.*, 1938, *31*, 661.
31. TOREK, F. First successful case of resection of thoracic portion of esophagus for carcinoma. *Surg., Gynec. & Obst.*, 1913, *16*, 614.
32. TOREK, F. Carcinoma of thoracic portion of esophagus. *Arch. Surg.*, 1925, *10*, 353–360.
33. WATSON, W. L. Carcinoma of oesophagus. *Surg., Gynec. & Obst.*, 1933, *56*, 884–897.
34. ZUPPINGER, A. Die Behandlung der Ösophaguskarzinome. *Ergebn. d. med. Strahlenforsch.*, 1936, *7*, 389–456.

Vol. 49, No. 5

ROENTGEN THERAPY OF "VIRUS" PNEUMONIA

By ALBERT OPPENHEIMER, M.D.
Department of Roentgenology, Laconia Hospital
LACONIA, NEW HAMPSHIRE

THE atypical pneumonia which has come to be designated as virus pneumonia[2] seems to be refractory to medical treatment. According to inquiries made at numerous institutions, roentgen therapy has not been used so far in the treatment of this disease. Hence the results of roentgen irradiation in a fairly large group of cases should be recorded.

As during previous epidemics of influenzal pneumonia—to which virus pneumonia is at least very closely related—the disease varies somewhat with the locality and with its own epidemic course. For instance, at a time when numerous cases with massive consolidations were observed in the Boston district, only small peribronchial foci were found in the patients examined some seventy miles to the north, in New Hampshire. Pleurisy, which has been a fairly common complication in other parts of the country, has not yet been noted in the cases in northern New England. The severity and duration of the clinical manifestations seem to increase as the present epidemic extends. Moreover, at a given time, the symptoms differ from case to case and are sometimes stormy, sometimes rather slight. Apart from these variations, physicians are generally agreed on the distinctive features of virus pneumonia: fever and infiltration of the lungs lasting several weeks; persistent cough; no response to the sulfonamide drugs; and slow convalescence.

Two main types have been observed in New Hampshire: (1) a massive consolidation usually not confined to one lobe, but involving adjacent parts of contiguous lobes, mainly in the perihilar areas, casting ill-defined globular shadows; this is often bilateral, with one side much more extensively affected than the other; (2) a more diffuse patchy infiltration of both lungs along the bronchi, with definite enlargement of the hila, sometimes with small foci resembling miliary tuberculosis; this corresponds to the peribronchitis and pneumonitis of previous epidemics. A more detailed analysis of the roentgen findings has been published very recently.[6] The roentgenologic differences, however, are not associated with clear-cut clinical differences. The course, duration, and severity of the illness are not characteristic of the one or the other type in the instances observed in this district. During November and December, 1942, the leukocyte counts were low in the pneumonitis group (3,000 to 5,000), and high in the presence of massive infiltration (over 12,000); but this difference has not been noted in recent months. Since most of the patients had received sulfonamides before admission, these counts are not very significant.

After the febrile stage, which lasted anywhere between five days and six weeks, most of the patients continued coughing, chiefly at night. The cough did not respond to drugs, inhalation, steaming, and the like, and kept the patients awake for hours at a time. The impression was given that the resulting lack of sleep was one of the factors which delayed recovery. The cough could be controlled by roentgen therapy. This encouraged us to use roentgen therapy during the acute stages as well.

Although the results of roentgen therapy of lobar pneumonia are well known,[5] there is little information available on roentgen treatment of atypical pneumonias.[4,5] During the past ten years, I have treated nonneoplastic lesions, including bronchopneumonia, with roentgen doses corresponding to about one-third to one-fifth of those commonly advocated in the treatment of inflammations.[5] These small doses approximate closely the doses recommended by Chamberlain[1] in a paper which does not seem to be sufficiently known. For the treatment of virus pneumonia, the follow-

ing factors were used in this series: 130 to 150 kv., according to the size of the chest and the thickness of skin and muscles; 30 ma.; 0.5 mm. Cu plus 1 mm. Al filtration; 50 cm. anode-skin distance; an average dose of 50 r (measured in air) through portals covering the involved parts of the lungs usually 20 by 20 cm. This technique was adopted after treatment with 100 r or more at early stages had induced severe systemic reactions with chills, convulsions, and cold sweats in 3 instances. These reactions are known to occur after roentgen therapy of other infections,[5] but do not seem to be necessary for achieving the desired therapeutic result in our experience.

According to the observations of Fried and Heidenhain,[3] the amount of radiation applied should increase with the duration of the inflammation: the more recent the lesion, the smaller should be the dose administered. Accordingly, about 35 to 45 r was given to children, and 50 to 60 r to adults, during the first two or three days after the onset of symptoms; but 50 to 70 r and 70 to 90 r respectively when the symptoms had persisted for about one week previous to treatment. No untoward reactions of any kind were observed with this treatment. In the presence of leukopenia, roentgen therapy did not induce a further drop in the leukocyte counts.

The results obtained in 56 cases of virus pneumonia and pneumonitis are given in Table 1. None of the cases had previously responded to medical treatment; and the failure to respond to sulfonamide therapy was considered a diagnostic sign.

TABLE I

SYNOPSIS OF CASES

Number of Cases	Duration of Illness before Roentgen Therapy	Duration of Symptoms after Roentgen Therapy	Cured*	Not Cured†
18	2–5 days	1–2 days	14	
		3–5 days	4	
22	6–14 days	1–2 days	4	
		3–5 days	15	3
16	Over 14 days	1–3 days	2	
		4–7 days	6	8
Total: 56			45	11

* "Cured" means disappearance of fever and symptoms, but not necessarily of the pulmonary infiltrations, within the period of days mentioned (see the text).

† "Not cured" means that the symptoms did not completely subside within the period of days mentioned, although subjective improvement was sometimes noted.

The therapeutic effect of roentgen treatment varied to some extent with the duration of the disease prior to irradiation. As a general rule, a single treatment was sufficient to bring about a return of temperature to normal within sixteen hours, as well as a considerable diminution of the cough and distress, in patients treated within a few days after the onset of symptoms. About twenty-four hours after the treatment, expectoration usually increased moderately in these cases, and most of them were discharged from the hospital after another day or two. The annoying cough which troubles the convalescence of untreated patients did not occur at all in the cases treated early. When, previous to irradiation, the disease had lasted for over a

week, one treatment usually resulted in a drop of temperature to slightly above normal, but the coughing spells tended to persist, and the temperature often rose again after an interval of three or four days. In the cases of this group, a second treatment, sometimes followed by a third one after forty-eight hours, was necessary to obtain relief and drop of the temperature to normal. In 2 patients treated sixteen and twenty-three days after the onset of symptoms, several irradiations with increasing doses (up to 300 r) failed to effect any therapeutic results. These observations suggest that roentgen therapy of virus pneumonia is useful mainly during the early stages of the disease.

The clinical improvement did not coincide with a regression of the pulmonary infiltrations. The course of the resolution was checked on roentgenograms in all the patients. In general, clinical improvement or cure preceded the disappearance of the infiltrations by about four days, but a decrease in density and size of the corresponding shadows was often noticeable as early as thirty-six hours after the treatment. Residual infiltrations were not observed to persist in the patients treated.

Five patients were referred for roentgen therapy several weeks after termination of the febrile stage because of persistent cough at night, associated with fatigue and inability to resume normal occupation. These patients were treated with doses of 90 r three to four times in the course of about two weeks. They were free of symptoms after this time and regained normal health rapidly.

In the patients treated during the febrile stages, the disappearance of fever and distress was entirely undramatic. There was no evidence of a crisis. With surprising uniformity fever and symptoms subsided gradually in the course of about sixteen hours, during which period most of the patients spent their first comfortable night after days of discomfort and dyspnea. The rate of pulse and respiration returned to normal gradually at the same time. In view of the severe reactions observed after treatment with larger doses, as above mentioned, one may perhaps attribute this uneventful and gradual recovery to the small r doses administered in this series.

Clearly the results of any mode of treatment are very difficult to ascertain accurately and impartially, especially as regards acute infections. It certainly cannot be proved that the 56 patients of this series would not have recovered as rapidly without roentgen therapy. Control series are not easy to evaluate since, in clinical medicine, no two cases are exactly alike. In two pairs of treated and untreated patients the findings were similar enough to be comparable. Two males of about the same general build, aged fifty-six and sixty-three, showed an infiltration 11 cm. in diameter in the central part of the left lung, and a smaller one, about 4 cm. in diameter, in the right base. Both were severely ill, with rapid pulse and respiration, temperatures about 103° F., and moderate cyanosis. One of them was treated on the third day of his illness with 50 r; sixteen hours later the temperature had dropped from 103 to 98.3° F., pulse from 160 to 84, and respiration from 60 to 24. The infiltration was found definitely diminished forty-eight hours after the treatment, and the lung fields were found free of abnormal shadows five days after the treatment. There was a slight recurrence of the cough on the fourth day, but the patient remained free of symptoms from the fifth day on. The other patient was not treated during the first sixteen days of his illness, and the infiltration was found to have increased during this time.

The second pair consisted of two girls aged six, with bilateral diffuse pneumonitis. In the treated child, symptoms and lesions disappeared seventy-two hours after irradiation; in the untreated, they persisted for twenty-five days.

These two pairs of cases seem to bear out the experience of many physicians in various parts of the country in regard to the course of virus pneumonia in patients not submitted to roentgen therapy. If we may

use these many hundreds of untreated cases in lieu of a control series, it would seem to be evident that roentgen therapy helps to shorten the duration of the disease materially.*

SUMMARY

1. Roentgen therapy with small doses of between 35 and 90 r resulted in clinical cure within a few days in 45 out of 56 cases of virus pneumonia.

2. The pulmonary consolidations disappeared within three to five days after roentgen treatment.

3. The results of roentgen therapy were best at early stages of virus pneumonia, but limited when irradiation was used later than two weeks after the onset of the disease.

4. Roentgen therapy was the most effective mode of treatment for the control of the persistent cough which delayed complete recovery during convalescence in patients who had not received irradiation during the febrile stage.

5. At early stages, the r doses applied should be small. Treatment with doses exceeding 100 r during the early stages resulted in alarming systemic reactions. No untoward reactions whatever were observed with the use of smaller doses.

* No distinction was made between "virus" pneumonia of adults and the so-called interstitial pneumonia (peribronchitis and peribronchiolitis) of childhood, since the two diseases are identical epidemiologically and virtually indistinguishable in their clinical course. Children seem to respond to roentgen therapy more uniformly and within shorter periods than adults.

REFERENCES

1. CHAMBERLAIN, W. E. Roentgen therapy with very small doses. *Acta radiol.*, 1926, *6*, 271–280.
2. EDITORIAL. Virus (?) pneumonia. *J. Am. M. Ass.*, Jan. 16, 1943, *121*, 197.
3. FRIED, C., and HEIDENHAIN, L. Röntgenbestrahlung und Entzündung. *Arch. f. klin. Chir.*, 1924, *133*, 624–665.
4. MCINTIRE, F. T., and SMITH, J. H. X-ray therapy in the treatment of pneumonia. *Texas State J. Med.*, 1937, *33*, 422–440.
5. PENDERGRASS, E. P., and HODES, P. J. Roentgen irradiation in the treatment of inflammations. AM. J. ROENTGENOL. & RAD. THERAPY, 1941, *45*, 74–106.
6. SEEDS, A. E., and MAZER, M. L. Virus pneumonia; roentgenographic characterization of recent virus pneumonitis with bronchopneumonia. AM. J. ROENTGENOL. & RAD. THERAPY, January, 1943, *49*, 30–38.

Vol. 49, No. 5

RADIATION HAZARDS DURING ROENTGENOSCOPY*

By THOMAS N. WHITE, Ph.D.,† DEAN B. COWIE, B.S.,‡ *and* ALFRED A. DE LORIMIER, M.D.§

INTRODUCTION

HAZARDS associated with roentgenoscopy have been emphasized repeatedly;[2,3,4,5,10,26,27,29,31] yet the history of roentgenology contains too many accounts of mal-effects and martyrdom due to careless practices or unsuspected injurious action of the roentgen rays.[8] The mistakes of yesteryears should serve to counteract mal effects today, and in the future. Unfortunately, though, the provision of adequate protection during roentgenoscopy is inherently difficult. It appears that unless there is accomplished some major increase in the sensitivity of fluoroscopic screens,[9] the roentgenoscopist must continue to risk exposures beyond the accepted "tolerance dose," or be restricted by somewhat unwieldy protective equipment.

From time to time, our radiological societies have initiated careful deliberations and recommendations as to tolerance limits of roentgen radiation.[1,7,20,34,35] Most of these estimates have been based upon "injuries to the superficial tissues; changes in the blood and derangements of the internal organs." More recently emphasis has been directed to susceptibility of the reproductive organs.[21,32] The "tolerance dose" so estimated is about two-tenths of a roentgen per day. Biological studies have indicated reason for concern as to mal-effects upon future generations—a genetic effect.[17,19,25,33] The accepted tolerance dose is, to the best of present knowledge, fairly conservative as far as the first group of injuries is concerned. On the other hand, laboratory experiments show no evidence of genetic recovery from injury by roentgen radiation. Therefore the "tolerance dose" may not be conservative with respect to the population as a whole. Since damage of this character would be irreparable, it appears wise to hold to the lowest practicable level the exposure of the genital organs of all who can have offspring.

Following the impetus given to roentgenology during the first World War, there were advocated in Europe many elaborate protective devices. Line drawings of a few of these are shown in Figure 1. It is probable that some of these units provide a degree of protection considerably greater than is demanded by our present standard of "tolerance dosage." In the United States, devices such as these have not found wide favor. Indeed, there has been a tendency to dispense with most protective aids (including gloves and apron) and to depend upon the shielding afforded by the lead glass of the fluoroscopic screen, the use of small roentgen beams, and upon speed and skill of examination.[23] It should be unnecessary to re-emphasize that the elimination of protective apparel leads to undesirable conditions where carelessness, ignorance or undue confidence in modern equipment exist.[15,22,28]

Various types of roentgenoscopic equipment are available in this country today. Though not comparable to the arrangements which have been recommended by some of the European roentgenologists, we have so-called "heavy duty" table units wherein the roentgen tube and shutter housing are completely enclosed by a table provided with metal side panels; we have so-called "light duty" table units wherein the roentgen tube and shutter housing are exposed, beneath or behind the table top, and now we also have to be concerned with the extensive use of bare essentials—

* Presented at the Forty-third Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 15–18, 1942.
† Associate Biophysicist, National Cancer Institute, Bethesda, Maryland.
‡ Research Fellow, National Cancer Institute, Bethesda, Maryland.
§ Colonel, Medical Corps; Commandant, Army School of Roentgenology, Memphis, Tennessee.

roentgen-ray equipment such as might be practical for use in the battle field.

There appears to be much reason for an evaluation of exposure intensities associated with these three general types of equipment. Extensive studies have been made of the intensity of roentgen radiation in the exit beam under fluoroscopic conditions.[11,12,13,14,24] It is probably safe to say that exposure between the patient and the greatest exposure is incurred thereby. The studies have included the consideration of primary roentgen radiation escaping from conventional "ray-proof" roentgen tubes and the various components of secondary radiation such as that emitted from fluoroscopic shutters, shutter housings, table tops, the patient (i.e. phantom) and fluoroscopic screen. We have not included the consideration of gross errors or structural

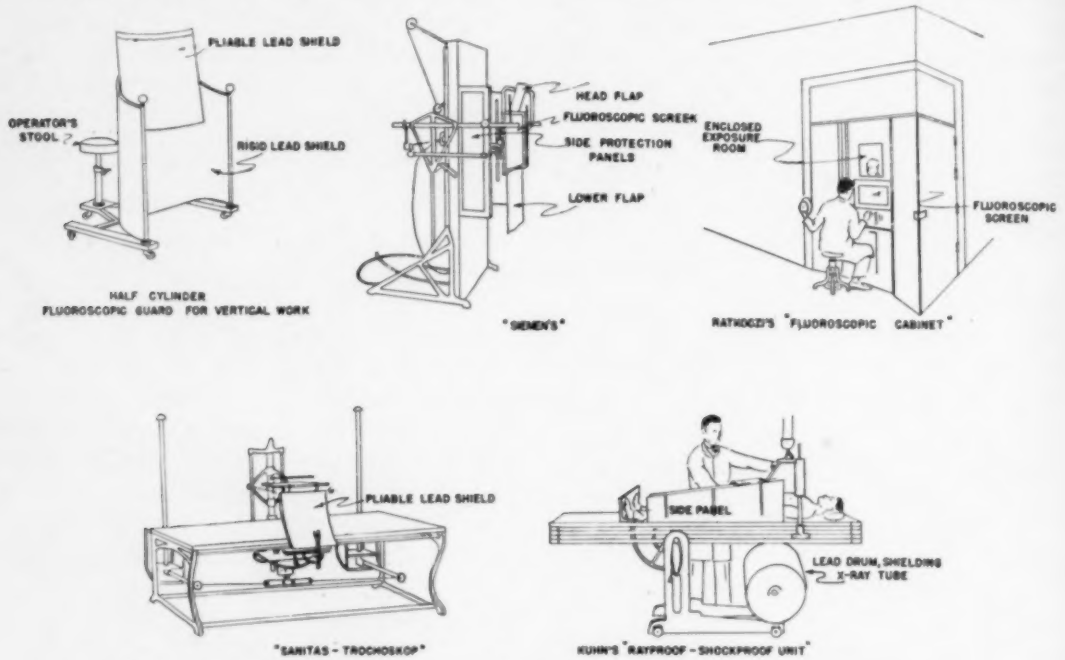


FIG. 1. Glocker's[18] choice of installations for protection during roentgenoscopy.

screen is practically independent of the type of table used. For this reason we have made few measurements at that location. On the other hand, few observers have given attention to exposure of the whole body of the roentgenoscopist, as affected by the general type of equipment. It is realized that the amount of radiation which a roentgenoscopist receives depends upon the physical protection provided by the equipment or shielding apparel, as well as upon the skill with which his work is performed. Just what are the dangerous conditions? What precautions should be observed?

The tests reported in this paper have been limited to conditions of horizontal roentgenoscopy, for it is believed that the flaws such as a misdirected primary beam or a "wide open" beam which might cover an area beyond the limits of the fluoroscopic screen.

OUTLINE OF EXPERIMENTAL PROCEDURE

Only the most essential experimental information is given in this section. Details which are not of general interest have been relegated to a technical appendix, to which the reader is referred by numbers prefixed by A.

The plan of this study was progressive. Starting with a "ray-proof" shock-proof roentgen tube, the leakage from which was first examined, there were added structural components typifying those of a horizontal fluoroscope: diaphragm (in place of shutters), filter, cone between tube housing and diaphragm, fluoroscop-

ic screen, two types of table top. After each addition the stray radiation was measured at suitable locations. From the changes in the amounts of stray radiation it was possible to assess the relative importance of the different structural components in adding to or reducing the stray radiation. There was then added a fiber board phantom (Technical Appendix A-1), roughly cubical in shape (about 20 cm. on edge); thereafter, an auxiliary shield between the diaphragm and the table top. These additions made possible a rough evaluation, at certain locations, of the secondary radiation from a patient, and the effect of the auxiliary shield upon the distribution of this radiation.

The side of the phantom on which these measurements were made was aligned roentgenoscopically with the border of the primary beam. Thus the full area of the beam was occupied by phantom material, while at the same time absorption of the secondary radiation emitted by the phantom was held to a minimum. Lateral additions of phantom material then permitted an evaluation, under well defined experimental conditions, of the extent to which body tissue *outside* the irradiated volume reduces the secondary radiation emitted *from* the irradiated volume.

The preceding tests were made with equipment possessing certain framework elements (not shown in the diagrams) which interfered to some extent with the free passage of secondary radiation from the phantom toward the lower levels. In order to overcome this difficulty and to provide a truer picture of the distribution of secondary radiation from a patient, both the apparatus and the phantom were reconstructed. The phantom was given an oval shape (Technical Appendix A-1) and distortion of the field of secondary radiation due to undesired structural elements was reduced to a minimum. Measurements were made at a sufficiently large number of locations to permit the construction of isodose (strictly speaking, isodose per unit time or iso-intensity) curves, showing graphically the distribution of the secondary radiation. There were determined the changes produced in this distribution due to a shift in the position of the phantom, and due to the addition of two common types of table.

Measurements of stray radiation were made with 0.25 r (full scale reading) condenser type Victoreen ionization chambers (Technical Appendix A-2). Actual exposure times ranged from one to six minutes. Since the total daily operating time of a roentgenoscopic roentgen tube is something like one hour (i.e., based on continuous operation), the intensities are presented in roentgens per hour, for easier comparison with the "tolerance dose" of 0.2 roentgen per day.

In some cases an indication of the penetrating power of the radiation was obtained by observing the reduction in chamber reading which was caused by wrapping the chamber with copper foil (Technical Appendix A-3). The results of these measurements are included mainly for possible future usefulness. So far as we know there is not at the present time sufficient information concerning the influence of quality of stray radiation on roentgen injury to warrant the drawing of any conclusions from these data.

Most of the measurements were made using 85 kv. (peak) and 5 ma., and with a shutter opening to give a field 20 by 20 cm. on the fluoroscopic screen, since it was considered that these conditions would give *more* rather than *less* than the average exposure. Occasional measurements, not recorded herein, showed that when the potential was reduced to 70 kv. (peak) and other conditions were kept constant, the secondary radiation intensity dropped by about 30 per cent. Enough measurements were made with a smaller field (10 by 10 cm. on the screen) to show the effect of field size.

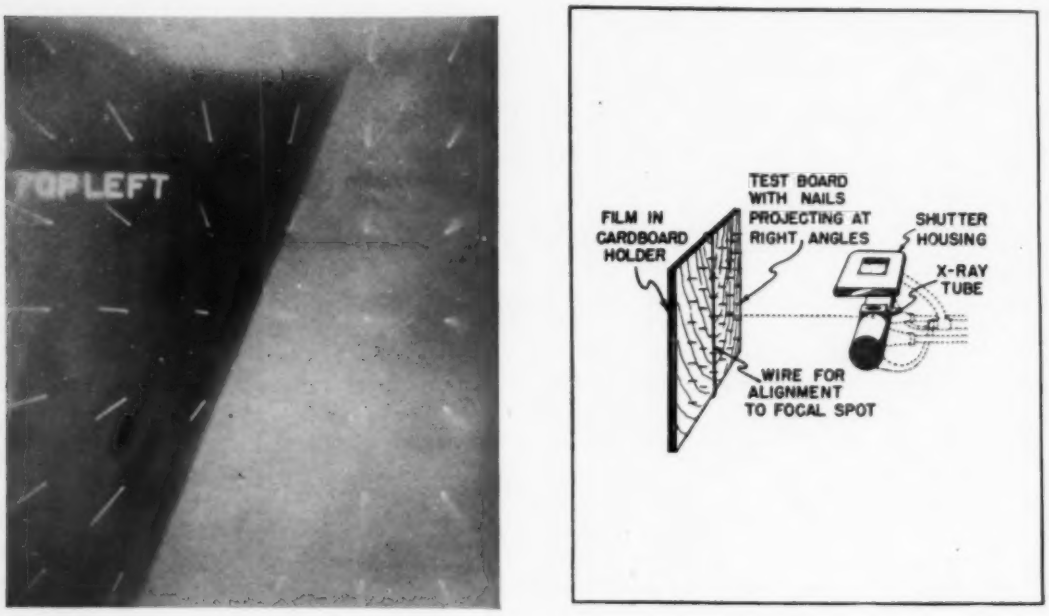
OBSERVATIONS AND DISCUSSION

Due to the variety of factors involved in this experiment it has been thought best to discuss the observations as they are presented.

The Roentgen Tube. The shock-proof tube used for most of the tests had been purchased under specifications calling for "ray-proofing" to the extent of 1.5 mm. of lead, which is the amount of protection advocated by the National Bureau of Standards Handbook HB 20 for general purpose protection against 100 kv. radiation. Figure 2 shows roentgenographically the stray radiation obtained when the exit portal of the tube housing was blocked off with 3 mm. of lead, and the conditions under which the film was obtained. The escape of primary radiation is evidenced both by the sharp cut-off at the intersection of the plane of the target face with the film and by one set of sharp nail shadows, all pointing toward the projection of the focal spot thereon. The

more diffuse nail shadows must be attributed to secondary or to stem radiation (or both). The cut-off at the top of the film is attributable to the shutter housing shown in Figure 2*b*. The "nail-board" method appears to have certain possibilities which were not fully investigated in these tests.

Figure 3*a* shows the geometrical relations of film and roentgen tube more accurately, and also the positions at which ionization measurements were made before and after the addition of supplementary protection on the roentgen tube housing.


TOP LEFT
TEST BOARD WITH NAILS PROJECTING AT RIGHT ANGLES
FILM IN CARDBOARD HOLDER
SHUTTER HOUSING
X-RAY TUBE
WIRE FOR ALIGNMENT TO FOCAL SPOT

a *b*

FIG. 2. Roentgenography of stray radiation from roentgen tube. *a*, film reproduction showing excess radiation (mostly primary) escaping from cathode sector ("top left"). Note the sharp demarcation of target face; also the multiplicity of the individual nail shadows—the more sharp and dense outlines being interpreted as being produced by primary radiation. *b*, showing the arrangement by which *a* was obtained.

In horizontal roentgenoscopy it is quite possible for the operator's legs to be nearly as close to the roentgen tube as were the ionization chambers in this test. At this distance undesirably large readings were obtained before supplementary absorbing material was added to the tube housing. As would be expected, the leakage from the bare housing was very sensitive to the potential at which the tube was operating. A reduction to a potential of 70 kv. (peak) caused a decrease of more than 80 per cent in the reading at the x position. With a reasonable allowance for operating conditions and distance, these results agree with some of those obtained in Braestrup's thorough survey[6] of this subject.

Qualitative or quantitative testings were accomplished in no less than thirty-six different tubes or tube units. These represented constructions by six well recognized tube manufacturers and twelve established roentgen-ray equipment manufacturers. In every instance some escape of roentgen radiation was demonstrated—thus confirming the fact that the term "ray-proof" is in contradiction to the fundamental properties of roentgen rays. This term may be responsible for a false sense of security. Taylor's finding[30]—"It is thus seen that the internationally accepted protective lead thicknesses all apply, under average dosage rate conditions, to a point 150 cm. from the

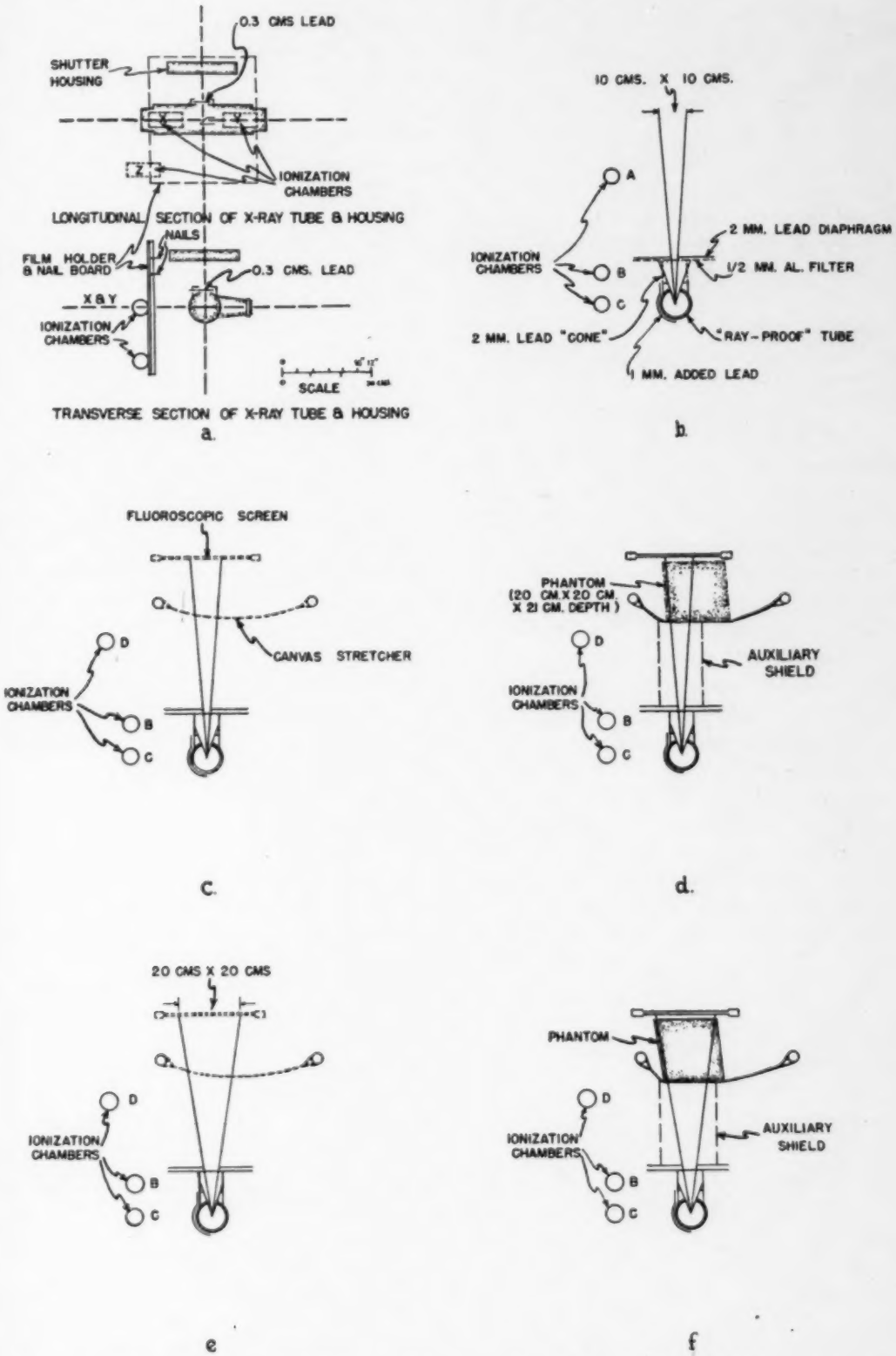


FIG. 3. Positioning of ionization chambers for progressive analysis of stray radiation emitted from the various components of a roentgenoscopic unit.

target"—deserves to be permanently recorded in the minds of all who must work close to operating roentgen tubes.

After adding an even more substantial absorber to the tube housing, the portal of the housing was opened, and the elements of a roentgenoscopic assembly were built up. The process is depicted in Figure 3, in which to avoid confusion, no more than two additions appear in any one diagram. Table 1 shows the effect of the additions with respect to intensities at the designated locations. Except as noted, the differences shown in the last column were obtained by subtracting the total roentgens per hour of one set-up from the total roentgens per hour of the next following set-up. It is recognized that in assigning significance to these differences, a certain degree of caution must be observed, since the effect of placing matter in a roentgen-ray field (either primary or secondary) is complex. Under the conditions of these tests certain increases or reductions in radiation can be assigned *mainly*, but not entirely, to certain causes, and the following discussion is subject to this qualification.

The Diaphragm (or Shutter) and Housing. In Figure 3*b* only a small fraction (about 19 per cent) of the primary beam passed through the opening in the diaphragm. The intensities observed at B and C differed little, therefore, from what would have been obtained had there been no opening in the sheet of lead. In view of the rather commonly held opinion that scattering from lead is less than scattering from matter of low atomic number, the effect of the addition of 0.5 mm. of aluminum is quite striking. Even with the filter present, the intensities below the level of the diaphragm are very large. It is clear that in special purpose equipment in which it is impractical to build the shutter housing onto the tube housing using absorbent material, some means must be found to cut off this radiation. The most desirable method must depend upon the type and use of the equipment, one example being given elsewhere.[16]

In conventional equipment, it is not practicable to bring a cone into contact with four shutter blades, and it is important therefore that the cone should extend into a protective structure which partially envelopes the shutters and associated operating mechanism. This is particularly important in the so-called "light duty" type of diagnostic table in which there is no metal side panel to absorb secondary radiation. The usefulness of substantial metal side panels in reducing secondary radiation from a patient is discussed later, but it should be mentioned here that we have found such panels to be very effective also in absorbing radiation from the tube side of shutter assemblies.

It will be noted that in this test the aluminum filter was placed in ar. unfavorable position with respect to the location designated as A in the diagram. Had the filter been placed at the exit portal of the tube housing, the final intensity at this position in Figure 3*b*, and the initial intensities at D in Figure 3*c* would undoubtedly have been even lower. The intensities obtained with nothing but air in the useful beam (the primary beam beyond the diaphragm) lead to an important conclusion: it is quite practicable to construct equipment such that there is practically no stray radiation other than that from solid matter in the useful beam. Obvious as this may seem, there is no difficulty in finding diagnostic units which do not meet any such basic requirement.

The Table Top and Screen. The radiation emitted from the table top and screen is ordinarily affected by the patient. However, it does occasionally happen that for one reason or another, the roentgen tube is energized with the shutters open and no patient on the table. The data indicate that under these conditions there is present an amount of stray radiation which is by no means negligible.

As would be anticipated, the secondary radiation from an ordinary table top ($\frac{3}{4}$ inch wood veneer with metal frame, borrowed from a conventional tilt table) is much greater than that from a canvas top (litter,

as used on United States Army Field Table).

The Phantom ("*Patient*"). With radiation of diagnostic quality very little of the primary beam is transmitted by a thick part of the body. Operating at 85 kv. (peak), primary transmission through the phantom of these tests was about 0.36 per cent. With a 20 by 20 cm. field on the screen the total radiation on the top side of the phantom was 0.11 r per minute in the absence of the screen. Of this amount about 16 per cent was primary radiation (Technical Appendix A-4). These observations are in substantial agreement with similar data obtained by Cilley, Kirklin and Leddy.[13]

From this it follows that in the presence of the phantom the screen could not have contributed appreciably to the radiation at the locations D, B, C. The effect of the phantom on the radiation from the table top is not easily ascertained. However, it has already appeared that little radiation is scattered from a canvas litter and the amount attributable to the phantom can therefore be estimated with sufficient accuracy by making subtractions in the way indicated by the asterisks in Table 1.

In agreement with previous investigators, it appears that the secondary radiation from the "patient" is of preponderant importance. Only in the case of the unprotected diaphragm was there found a greater amount of radiation from any other single component of the assembly. At the knee position of the operator, when large fields are used the radiation from the phantom is greater than that escaping from the bare tube housing (cf. position c and x). The ratio between these components depends of course upon the shutter opening. It appears that with a small portal (5 by 5 cm. on the screen), the radiation escaping from the tube housing might be the more important factor.

The Auxiliary Shield. The positions B, C, D were chosen at the outset to be sensitive to the effect of the final addition of the auxiliary shield. At position D the cylinder has a definite effect even though only a small fraction of the irradiated volume of the phantom is shaded from the "view" of the ionization chamber. With respect to lower levels, the shield is much more effective. The region throughout which any such shield affords protection will obviously increase with the area of the shield and its proximity to the patient. The present results may profitably be compared with those, presented later, which were obtained with a metal side panel on the table, since a "totally enclosed" table functions in certain respects like an auxiliary shield of maximum possible area.

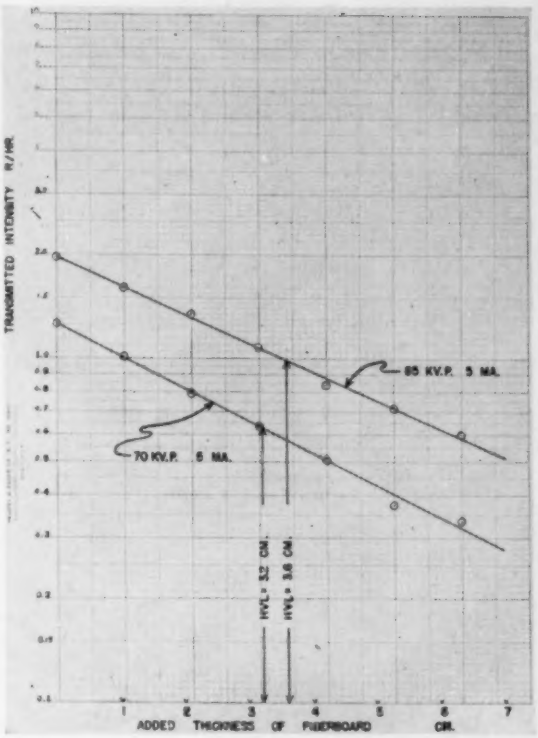


FIG. 4. Absorption of secondary radiation by phantom material (or patient's tissues).

Absorption of Secondary Radiation by the Phantom. Except for some of the secondary rays generated at the border of the primary beam, there must occur some absorption of secondary rays within the irradiated volume of the phantom. A direct investigation of this process is not readily accomplished. However, as previously mentioned, this factor can be reduced to a minimum by

aligning the phantom as depicted in Figure 3. The addition of phantom material makes possible a determination of the protective effect of tissue outside the irradiated volume. Figure 4 shows the result so obtained with ionization chamber placed at the same level as the phantoms and at a distance of 21 cm. from the phantom. There was not much difference in absorption as dependent upon the potential at which the primary radiation was generated. The intensity of the secondary radiation was reduced to 50 per cent by traversal of about 3.5 cm. of phantom material. Since this thickness is considerably less than the amount of patient's tissue ordinarily expected to be present between the path of the primary beam and the roentgenoscopist, it is seen that the patient's body serves appreciably in reducing exposure. The protection so afforded is insufficient of itself, but it is well worth utilizing so far as clinical procedures permit.

TABLE I

Figure	Set-up	Position of Ionization Chambers	Total r per Hour	r per Hour Attributable to Added Component
3 *a*	(1) Exit portal of tube housing blocked with 3 mm. sheet lead	X	0.38	
		Y	0.20	
	(2) Tube housing enveloped by lead rubber—equivalent to 0.5 mm. lead	X	0.05	−0.33
		Y	0.02	−0.18
3 *b*	(3) Bare diaphragm (10 by 10 cm. portal at 66 cm. focal-screen level)	A	0.24	
		B	8.11	
		C	14.6	
	(4) Filter added (0.5 mm. aluminum)	A	0.30	+0.06
		B	2.5	−5.6
		C	3.1	−11.5
	(5) Cone added between tube housing and diaphragm (2 mm. sheet lead; diameter 9.5 cm.; length 8.5 cm.)	A	0.30	
		B	0.06	−2.44
		C	0.06	−3.04
3 *c*	(6) No change	D	0.06	
		B	0.06	
		C	0.06	
	(7) Fluoroscopic screen added (to level 66 cm. above focal spot)	D	0.30	+0.24
		B	0.12	+0.06
		C	0.12	+0.06
	(8) Canvas litter added as table top	D	0.30	very small
		B	0.12	very small
		C	0.12	very small
3 *d*	(9) Phantom added (21 cm. total thickness of fiber board—upon canvas litter as table top)	D	1.38	+1.32*
		B	.78	+0.72*
		C	.72	+0.66*
	(10) Auxiliary shield added between diaphragm and canvas litter table top	D	1.14	−0.24
		B	.06	−0.72
		C	.06	−0.66
3 *e*	(11) Diaphragm enlarged to produce 20 by 20 cm. portal at screen (compare 10 by 10 cm.)	D	0.18	
		B	0.12	
		C	0.06	
	(12) Canvas litter added as table top	D	0.36	+0.18
		B	0.24	+0.12
		C	0.18	+0.12
	(13) Conventional table top substituted for canvas litter	D	0.84	+0.48
		B	0.60	+0.36
		C	0.50	+0.32
	(14) Fluoroscopic screen added (canvas litter again in place)	D	1.14	+0.78†
		B	0.63	+0.39†
		C	0.48	+0.30†
3 *f*	(15) Phantom added	D	3.85	+3.67‡
		B	2.30	+2.18‡
		C	2.30	+2.24‡
	(16) Auxiliary shield added between diaphragm and canvas litter table top	D	2.76	−1.09
		B	0.12	−2.18
		C	0.12	−2.18

* Differences obtained by subtraction of total r/hr. of set-up (6).
† Differences obtained by subtraction of total r/hr. of set-up (12).
‡ Differences obtained by subtraction of total r/hr. of set-up (11).

Size of Portal. The data of Table 1 show that, as would be expected, the amount of secondary radiation from the phantom increases rapidly with the size of the beam. Measurements in connection with the oval phantom (see following) show the quantitative relationship more exactly.

Kilovoltage and Milliamperage Factors. The data of Figure 4 show that at equal currents the lateral component of secondary radiation from the phantom is greater at 85 kv. (peak) than at 70 kv. (peak) by from 55 to 85 per cent, depending upon the amount of intervening absorbing material. Other conditions being equal, the intensity of secondary radiation should be strictly proportional to the milliamperage. It follows that at 70 kv. (peak), 5 ma., and at 85 kv. (peak), 3 ma., the lateral scattering should be about the same, and in both cases about 40 per cent less than at 85 kv. (peak), 5 ma. It is of course understood that this percentage would not be expected to hold true for a comparison of 70 kv. (peak), 5 ma. on a chest with 85 kv. (peak), 3 ma. on an abdomen.

The Distribution of Secondary Radiation from Material in the Useful Beam. The following tests were performed to obtain a more detailed picture of the all-important secondary radiation from a patient, and to show the influence of certain important factors on this distribution. Figure 5 is self-explanatory, and little more need be said about procedure than that measurements were made at 6 inch horizontal and vertical intervals throughout the region where iso-

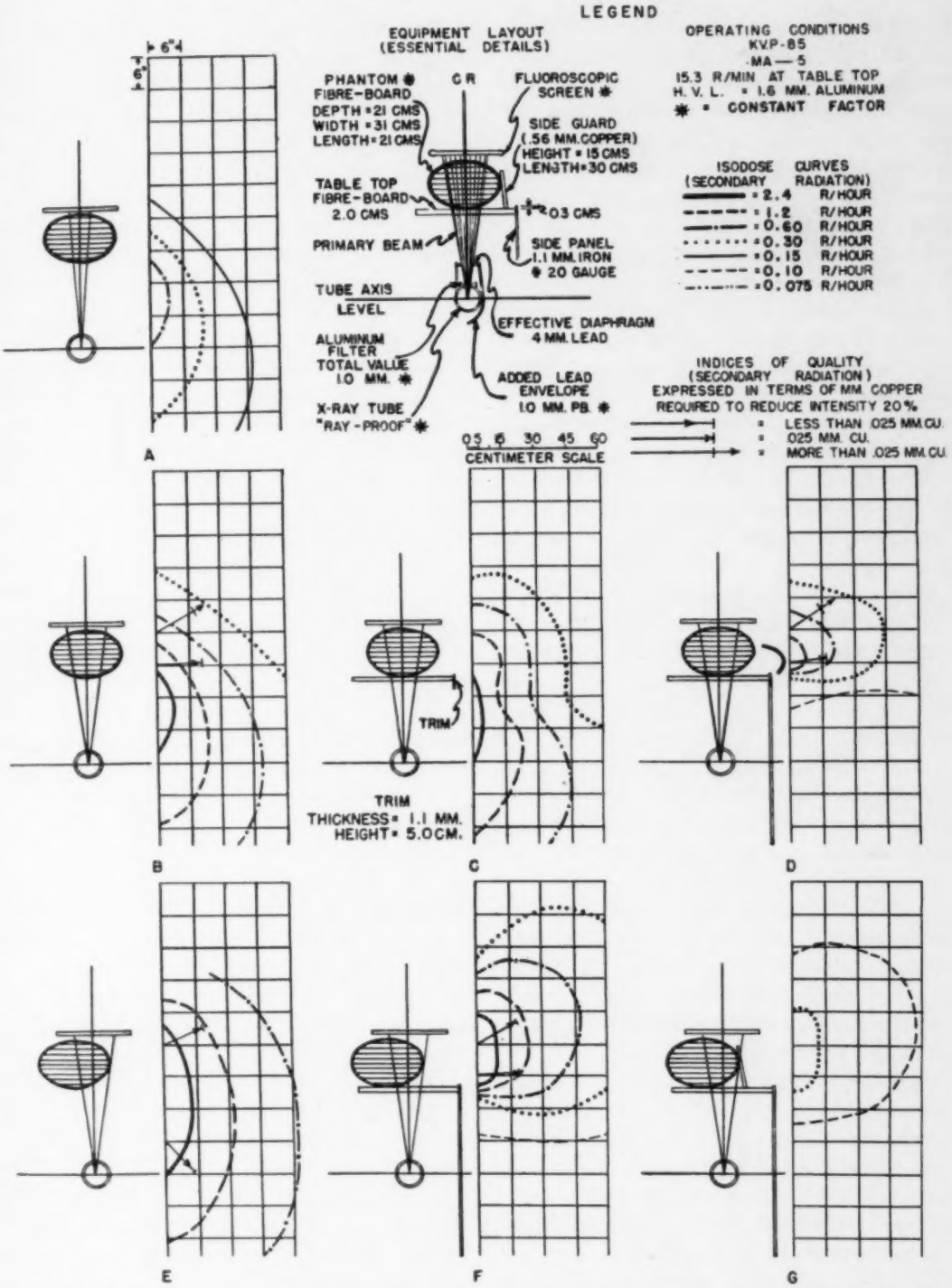


FIG. 5. Distribution of secondary radiation from phantom as affected by various roentgenoscopic conditions. A, primary field 10 by 10 cm.^{2} at level of fluoroscopic screen; phantom suspended immediately beneath screen—no table top. B, same as above except primary field was 20 by 20 cm. C, table top with iron trim added below phantom. D, iron side panel added; iron trim removed. E, same as in B but edge of beam grazing phantom. F, same as E with table top and side panel added—as in D. G, same as F with protective side guard.

dose curves are shown. Care was taken that there should be practically no stray radiation other than from material in the useful beam, and all auxiliary supporting structures were so disposed as not to distort the secondary radiation field under examination.

The conditions of roentgenoscopy are too complex to warrant any attempt at theoretical prediction of distribution of secondary radiation. There are, however, certain important factors, the magnitude of which can be estimated roughly, and an understanding of these factors is of aid in the mental integration of the experimental observations which follow. Confining attention to conditions similar to those with which we are here concerned, the most important considerations may be summarized as follows:

(1) Due to the strong and approximately exponential attenuation of the primary radiation, half the total scattering must occur in considerably less than half of the irradiated body volume. A reasonable estimate is that about half of the scattering occurs in the first 3 or 4 cm. of tissue traversed by the primary beam.

(2) Neglecting absorption of the scattered radiation, and taking the intensity of forward scattering as 100 per cent, the lateral and back scattering may be expected to be roughly 45 and 65 per cent respectively.

(3) Due to the situation set forth in (1) above, the radiation scattered in a forward direction must traverse, on the average, a much greater amount of tissue than that scattered in a backward direction. Due to absorption in tissue, the radiation which escapes in a forward direction must be weaker than that which escapes backward. An excess in the backward direction of 10-fold or more is to be expected.

While the backward versus forward aspect of the picture should be relatively insensitive to minor variations in size, shape or position of the body in the beam, this cannot be true of laterally escaping radiation. The amount of absorbing tissue traversed by laterally scattered radiation must depend rather critically upon these factors, and although even the roughest estimates are of little value, useful qualitative predictions can readily be made in the light of the considerations which have just been advanced.

Disregarding absorption, theory indicates that the radiation scattered in a backward direction should be somewhat less penetrating than that scattered in a forward direction. Differences in the amount of body filtration in these directions can only enhance this effect. It is therefore to be expected that appreciable differences will exist in the penetrating power of the rays escaping in different directions, those escaping in a general backward direction being definitely "softer" in character.

Discussing now the isodose curves* of Figure 5, we may return again briefly to the question of the influence of the size of portal. Under the conditions shown in Figure 5, A and B, the areas of the fields are 10 by 10 cm., 20 by 20 cm., respectively, and the ratio of the areas is therefore 1:4. In Figure 5A, the 0.60 r per hour isodose curve lies in the same position as the 2.4 r per hour curve in Figure 5B; the 0.30 r per hour curve in A has the same position as the 1.2 r per hour curve in B; etc. It is seen that the intensity of secondary radiation is nearly proportional to the area of the roentgen-ray beam on the fluorescent screen, other conditions being equal. The fact that this proportionality holds so accurately in this particular test is undoubtedly attributable to the symmetry of the conditions. Had the body been irregular in shape, or disposed asymmetrically in the beam, a change in the average absorbing path of secondary radiation would undoubtedly have led to some lack of proportionality.

It is to be noted that in Figure 5A the 0.15 r per hour curve occurs in such a position that the feet of the operator will not

* Appreciation is expressed for the care with which these many measurements were made by P. D. Kueck and Henry Meyer of the National Cancer Institute.

receive an excessive dose even though these regions are unprotected. These observations support the emphasis placed by a number of investigators on the protective value of using the smallest practicable size of field.

Comparison of B and E (Fig. 5) shows the reduction in secondary intensity due to the presence of body tissue between the operator and the path of the primary beam in the patient's body. Alongside the phantom the intensity in Figure 5B is from one-half to one-fourth the intensity at corresponding points in Figure 5E.

A simple table top, such as is found in so-called "light duty" units, alters somewhat the distribution of secondary intensity. This alteration is of little practical significance. There is a slight increase in intensity at upper levels probably due to the fact that radiation from the table top can reach certain points without traversing as much of the phantom as required for the phantom radiation itself. At the level of the table top, and just below it, the table top provides some shielding due to the fact that many of the rays reaching this region have to traverse a long path through the material of the table.

At levels well below the bottom of the phantom, the relative distribution of secondary intensity is practically unaffected by any of the factors so far considered. With due allowance for the smaller beam energy of condition A (Fig. 5), the positions of corresponding isodose curves at the lower levels are practically the same in A, B, C and E. On the other hand, the intensity distribution of the more laterally emitted secondary radiation is quite sensitive to variation in conditions. These observations are in good agreement with the theoretical considerations which have been outlined.

The relatively strong field of secondary radiation below the level of the phantom can be practically eliminated by steel side panels of moderate thickness, such as may be found in many so-called "totally enclosed" roentgenoscopic tables. This is seen in D, F and G, Figure 5. It is to be noted, however, that the conditions of these tests differ in one respect from practical conditions in a table of this type, which ordinarily possesses a horizontal slot to permit loading of the cassette tunnel. Unless some accessory protective structure is present, a beam of secondary radiation can escape through this slot. A very satisfactory accessory would be a properly constructed auxiliary shield. As pointed out previously, the protective utility of this device depends upon its area, and proximity to the patient. It has been remarked by Braestrup[6] that on many tables there is considerable clearance between the "trochoscope cone" and the table, to avoid interference with the Potter-Bucky diaphragm. There have come to our attention only two tables in which construction was all that would be desired in this respect.

It is possible to obtain a many-fold reduction in secondary intensity at levels beside the phantom without completely walling off the area between the screen and the table top. Comparison of the results of test G with those of test F (Fig. 5) shows an 8-fold reduction produced by as little as 0.5 mm. copper extending over a little more than a half of this area. From time to time through many years, various investigators have advocated lead rubber curtains hanging from the sides of the screen, or similar devices. From the present results it can be seen that such devices have great protective effectiveness. Apparently practical problems of manipulating the patient have discouraged wider acceptance of them. It is our opinion that there is still the possibility of improvement in the compromise between requirements of protection and requirements of making an examination efficiently. However, even without any additional protective gadgets, minor modifications of procedures in the light of a clear mental picture of the secondary radiation field can go far in reducing exposure of the roentgenoscopist.

SUMMARY AND CONCLUSIONS

An evaluation of radiation intensities from various sources and for various strata,

applicable to the position of the roentgenoscopist during horizontal roentgenoscopy, has been accomplished by means of ionization measurements. These studies have indicated the following:

1. There is an escape of considerable roentgen radiation from conventional "rayproof" roentgen tubes. The term "rayproof" is misleading. Auxiliary protection such as a metal side panel or lead protective apron is often needed beyond the sphere of the roentgen tube housing. This supplementary protection is most needed when operating at relatively high potentials (e.g., above 80 kv., peak) and short distances (e.g., 12 inches from tube to legs of operator). It is especially important as far as the cathode end of the tube is concerned.

2. Large amounts of secondary radiation emanate from the irradiated side of lead shutters. Unless cut off by a cone extending from the tube housing to the shutters, or by some equivalent shield, this radiation is likely to overexpose the shins and feet of the roentgenoscopist.

3. With no patient present, the operator may still receive appreciable amounts of secondary radiation from the roentgenoscopic screen and from conventional table tops. The radiation from a very thin light table top, such as the United States Army litter, is very small.

4. The patient is usually responsible for by far the greatest amount of secondary radiation. The downward and outward components of this radiation are of the greatest intensity. In spite of their much greater distance from the patient, the unprotected legs of a roentgenoscopist could receive from this source exposures almost as great as would his unprotected hands if exposed to the exit beam between patient and the roentgenoscopic screen.

Metal side panels, such as are found on substantial totally enclosed tables of the "heavy duty" type, are very effective in cutting off this backscatter from the patient and table top. These panels are also of value as shields against the other sources of stray radiation mentioned in 1 and 2 above.

Tables which are not totally enclosed—"light duty" and field types—can provide nearly the same protection if equipped with a well designed auxiliary shield. The combination of such a shield on the table with a lead rubber apron on the roentgenoscopist is more protective than the "heavy duty" type of table alone.

5. The patient gives off secondary radiation in amount almost directly proportional to the dimensions (scope) of the primary beam. Thus, for example, with 20 by 20 cm. under examination on the screen the secondary intensity is at most points about four times as great as with only 10 by 10 cm. illuminated. This observation emphasizes again the importance of using the smallest field dimensions possible—a procedure beneficial in reducing the exposure of the patient as well as of the roentgenoscopist.

6. The amount of radiation scattered laterally by the patient is about the same at 85 kv. (peak), 3 ma. as at 70 kv. (peak), 5 ma. The difference in penetrating power of the radiations so scattered appears too small to be of practical significance. Thus, if equally good roentgenoscopic results are obtainable at 85 kv. (peak), 2 ma. as at 70 kv. (peak), 5 ma., the higher potential is preferable from the point of view of protection of the roentgenoscopist.

7. A considerable absorption of secondary radiation may occur in the tissues of the patient. When the primary beam is allowed to permeate those tissues nearest to the roentgenoscopist without there being any intervening portion between the limits of the beam and the lateral wall, the radiant intensity is about twice that which obtains when even so little as 3 cm. of tissue intervenes to filter the rays. This fact should serve as a warning against prolonged viewing of the lateralmost tissues of a patient, unless there is provided for the roentgenoscopist adequate protection (such as a lead rubber apron or a lead protective shield hanging from the screen).

8. The forward and lateral components of the secondary beam are of the more

penetrating quality of ray. Most commonly used types of equipment permit considerable exposure on the arms and shoulders of the roentgenoscopist from these rays. These facts prompt the recommendation that protective gloves of long dimensions be worn.

9. These studies have indicated that if the several sources of stray radiation are fully appreciated, satisfactory protection can be incorporated even into light and easily maneuverable equipment. If a lead protective apron and gloves are worn by the operator to supplement well designed built-in protection, he can realize security against roentgen radiation exposure, except for very limited portions of his body such as his arms and shoulders, perhaps. Except for these parts, the exposures can easily be kept well below conservative estimates of the tolerance dose; well below 0.04 r per hour, with the consideration of continuous roentgenoscopic activity or less than 0.1 r for a strenuous ten hour day of intermittent roentgenoscopy. It should be borne in mind and emphasized that with *any* of the present day equipment (well designed "heavy duty," "light duty" or Army field units), a considerable exposure is incurred by parts of the body such as the shoulders—a quantity of the order of ten times the accepted tolerance dose.*

We wish to express our appreciation to Sergeant H. B. Kline of the Army Medical School for the several drawings.

TECHNICAL APPENDIX

A-1. Phantom consisted of blocks of fiber board, commonly called "masonite," average thickness, 0.53 cm.; average density, 1.04 gm/cc.

The "oval" phantom was constructed by cutting fiber board sheets and stacking them together so that the contour approximated closely an ellipsoidal cylinder of major axis 31 cm., minor axis 21 cm., length 20 cm. The stack was bound together with twine.

A-2. There was some concern as to trust of conventional ionization chambers for these measurements because of the relatively long wave length characteristics of the beam and the thickness of the wall of the chambers. Therefore a test run was conducted using a chamber with a graphited paper wall. With it the readings were only 6 per cent greater when operating at 85 kv. (peak) or 7 per cent greater at 70 kv. (peak)—both as compared with tests with the conventional wall. A constant error of this magnitude was considered unimportant for these comparative studies and therefore the standard chamber was used throughout.

A-3. The quality of roentgen radiation is ordinarily determined using absorbers placed at some distance from the ionization chamber, in order to avoid the effects of secondary radiation from the absorber, which may be quite considerable. In cases such as this, where the source of measured radiation is extended over a considerable volume, and different intensities are being received from different directions, the technique chosen appeared to be preferable to the more conventional procedure. On account of the quality of the radiation, aluminum would have been preferable to copper, but none was available in suitable form at the time the measurements were made.

A-4. Discrimination between primary and secondary radiation was accomplished in the following way: It was assumed that above the phantom the radiation consisted of two components, a primary component varying inversely as the square of the distance from the focal spot, and a secondary component varying inversely as the square of the distance from some unknown point in the phantom. On this basis there was derived a simple formula containing three arbitrary parameters which could be adjusted to obtain reasonable agreement with a series of measurements at different distances above the phantom. The values of two of these parameters were then sufficient to determine the intensities of the primary and secondary components at the upper surface of the phantom.

* For discussion see page 659.

REFERENCES

1. American Roentgen Ray Society, Proceedings of the Annual Meeting, 1920.
2. Barclay, A. E. Dangers of roentgenoscopy. Am. J. Roentgenol. & Rad. Therapy, 1934, *32*, 699–700.
3. Barclay, A. E., and Cox. S. Radiation risks of the roentgenologist. Am. J. Roentgenol. & Rad. Therapy, 1928, *19*, 551–561.
4. Benner, S. Strahlungsmessungen an mit radiologischen Arbeiten beschäftigtem Personal. *Acta radiol.*, 1933, *14*, 623–629.
5. Bouchacourt, L. Sur la protection des radiologistes pendant les examens radioscopiques. *J. de radiol. et d'électrol.*, 1930, *14*, 489–494.
6. Braestrup, C. B. X-ray protection in diagnostic radiology. *Radiology*, 1942, *38*, 207–216.
7. British X-ray and Radium Protection Committee. X-ray and radium protection. *J. Roentg. Soc.*, 1921, *17*, 100-103.
8. Brown, Percy. American Martyrs to Science through the Roentgen Rays. Charles C Thomas, Springfield, Ill., 1936.

9. Chamberlain, W. E. Fluoroscopes and fluoroscopy; Carman lecture. *Radiology*, 1942, *38*, 383–413.
10. Chantraine, H., and Profitlich, P. Ueber den Schutz des Arztes und seiner Gehilfen vor den Röntgenstrahlen. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1928, *38*, 121–128.
11. Cilley, E. I. L., Leddy, E. T., and Kirklin, B. R. Dangers of roentgenoscopy and methods of protection against them. II. Some considerations of the size of the beam used in roentgenoscopic examination. Am. J. Roentgenol. & Rad. Therapy, 1934, *32*, 805–807.
12. Cilley, E. I. L., Leddy, E. T., and Kirklin, B. R. Dangers of roentgenoscopy and methods of protection against them. III. The protective power of the barium-filled stomach. Am. J. Roentgenol. & Rad. Therapy, 1935, *33*, 88–92.
13. Cilley, E. I. L., Kirklin, B. R., and Leddy, E. T. Dangers of roentgenoscopy and methods of protection against them. IV. A detailed consideration of the doses received by the fingers of the examiner. Am. J. Roentgenol. & Rad. Therapy, 1935, *33*, 390–395.
14. Cilley, E. I. L., Leddy, E. T., and Kirklin, B. R. Dangers of roentgenoscopy and methods of protection against them. V. Some considerations of the "dose" received during examination of the colon. Am. J. Roentgenol. & Rad. Therapy, 1935, *33*, 787–792.
15. Cowie, D. B., and Scheele, L. A. Survey of radiation protection in hospitals. *J. Nat. Cancer Inst.*, 1941, *1*, 767–787.
16. de Lorimier, A. A., Cowie, D. B., and White, T. N. Protective features provided with the United States Army field roentgenoscopic equipment. Am. J. Roentgenol. & Rad. Therapy, May, 1943, *49*, 653–661.
17. Demerec, M. Heredity and radiation. *Radiology*, 1936, *27*, 217–220.
18. Glocker, R. Prinzipien des Strahlungs- und Hochspannungsschutzes und ihre technische Durchführung. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1931, *44*, 241–253.
19. Henshaw, P. S. Biologic significance of tolerance dose in x-ray and radium protection. *J. Nat. Cancer Inst.*, 1941, *1*, 789–805.
20. International X-ray and Radium Protection Commission. International Recommendations for x-ray and radium protection. *Radiology*, 1934, *23*, 682–685.
21. International X-ray and Radium Protection Committee. International Recommendations for x-ray and radium protection. Am. J. Roentgenol. & Rad. Therapy, 1938, *40*, 134–138.
22. Leddy, E. T. Causes of roentgen-ray dermatitis among physicians. Am. J. Roentgenol. & Rad. Therapy, 1936, *36*, 510–511.
23. Leddy, E. T. Dangers of roentgenoscopy. (Editorial.) Am. J. Roentgenol. & Rad. Therapy, 1937, *38*, 924–927.
24. Leddy, E. T., Cilley, E. I. L., and Kirklin, B. R. Dangers of roentgenoscopy and methods of protection against them. I. General review of the problem. Am. J. Roentgenol. & Rad. Therapy, 1934, *32*, 360–368.
25. Muller, H. J. The effects of roentgen rays upon the hereditary material. Chap. XVII in: The Science of Radiology. Otto Glasser, Editor. Charles C Thomas, Springfield, Ill., 1933.
26. Petzoldt, H. Ionometrische Messungen des Strahlenschutzes in medizinischen Röntgeninstituten. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1934, *49*, 406–415.
27. Schlechter, E. Streustrahlenschutz in der Diagnostik. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1926, *34*, 946–950.
28. Stevenson, C. A., and Leddy, E. T. Dangers of reducing fractures under the roentgenoscope and methods of protection against them. Am. J. Roentgenol. & Rad. Therapy, 1937, *37*, 70–82.
29. Taft, R. B. Stray radiation under actual conditions. Am. J. Roentgenol. & Rad. Therapy, 1941, *46*, 373–375.
30. Taylor, L. S. Economic features of x-ray protection. *Radiology*, 1940, *34*, 425–437.
31. Taylor, L. S. Roentgen-ray protection. Chap. XIX in: The Science of Radiology, Otto Glasser, Editor. Charles C Thomas, Springfield, Ill., 1933.
32. Taylor, L. S. X-ray protection. *J. Am. M. Ass.*, 1941, *116*, 136–140.
33. Timoféeff-Ressovsky, N. W. Experimentelle Mutationsforschung in der Vererbungslehre. Theodor Steinkopff, Dresden, 1937.
34. X-ray Protection. National Bureau of Standards Handbook No. 15, 1931.
35. X-ray Protection. National Bureau of Standards Handbook No. 20, 1936.

Vol. 49, No. 5

PROTECTIVE FEATURES PROVIDED WITH THE UNITED STATES ARMY FIELD ROENTGENOSCOPIC EQUIPMENT*

By ALFRED A. DE LORIMIER, M.D.,† DEAN B. COWIE, B.S.,‡
and THOMAS N. WHITE, PH.D.§

INTRODUCTION

PROTECTIVE features, concerned both with electrical and radiation hazards, are usually provided at the cost of increased bulk and weight. They might readily be overlooked where ease of manipulation and maneuverability are required Yet these features are of the greatest importance to such equipment, particularly when it is to be used under conditions of stress such as characterize activities in the Zone of Combat.

At first sight, our Army field roentgenoscopic equipment may present the appearance of shortcomings so far as protection from roentgen radiation is concerned. The provisions which have been incorporated into the design of our two types of table units may not be immediately evident. At least they have not been noted by a number who have spoken or written about this equipment.

For instance, one well qualified roentgenologist wrote as follows: "I understand that Dr. —— has just reported that a Field X-ray Unit scatters considerable radiation and the amount radiating to the head and neck is greater than the daily tolerance dose. Because of this I am extremely anxious to protect my men and myself from excessive exposure. I would rather have just one or two x-ray machines and be adequately protected than to have a display of eight or nine machines and have no protection."

The expression of another has been published as follows: "It looks to me to be the most flagrant violation of the rules of fluoroscopy that I have ever seen."

Such expressions appear to have become widely heard. They have reached the ears of roentgen-ray technicians. Frequently, we have received inquiries such as the following: "What are the needs for roentgenographic technicians in the Service? I understand that there is a considerable hazard associated with this work in the Army. A friend told me that one is likely to become sterile in the course of such an assignment; is this true?"

Our usual explanation has been that no hazard exists without carelessness in use of the equipment and that no harm is to be expected as a result of roentgenologic activities with the Army, for adequate protection has been provided.

It is doubtful if the usual brief and catagorical assurances can dispel entirely the fears which have prompted these remarks and inquiries. Yet time has rarely been available to give more detailed and satisfying answers.

Actually, there has been considerable thought about this matter. The basic design provided many features of protection and the several manufacturers* have cooperated to the greatest extent. They have never hesitated to incorporate improvements beyond the requirements described in our specifications and they have initiated considerable investigation themselves.†

The fundamentals pertaining to the vari-

* Appreciation is expressed to the X-ray Division of the Westinghouse Electric and Manufacturing Company, who have been constructing the all-purpose table unit; to the Picker X-ray Corporation, who have developed the lighter weight essentially roentgenoscopic unit, and to the H. G. Fischer Company, who also are engaged in manufacturing the larger unit.

† Particular respect is paid to Mr. E. R. Goldfield of the Picker X-ray Corporation for the very detailed testings which have been performed under his supervision.

* Presented at the Forty-third Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 15–18, 1942.
† Colonel, Medical Corps; Commandant, Army School of Roentgenology, Memphis, Tennessee.
‡ Research Fellow, National Cancer Institute, Bethesda, Maryland.
§ Associate Biophysicist, National Cancer Institute, Bethesda, Maryland.

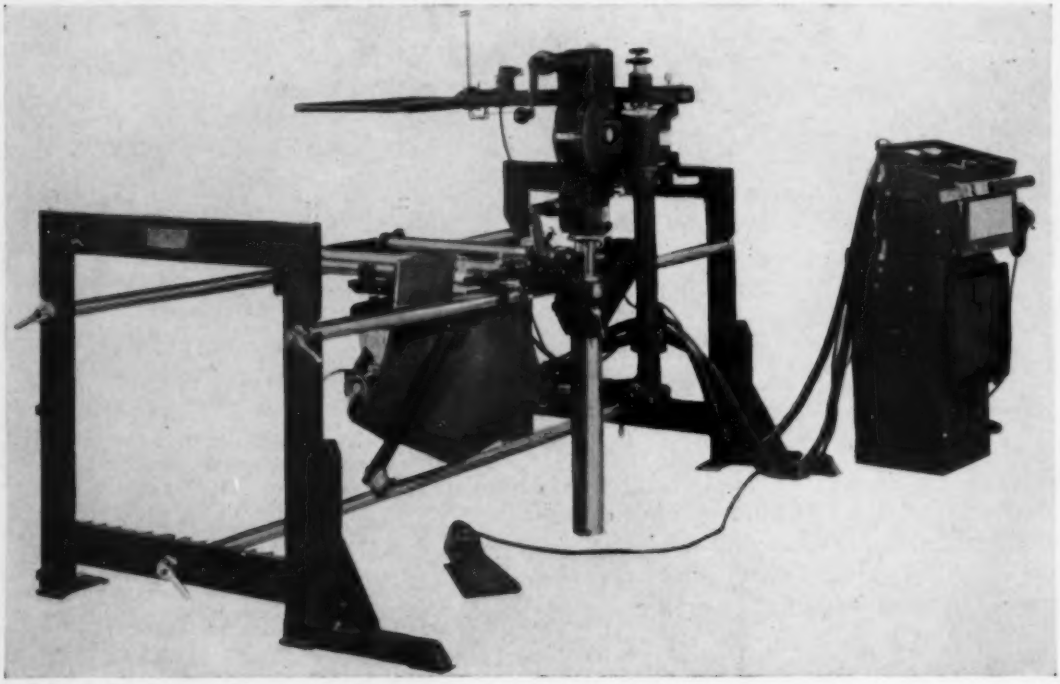
ous sources of radiation exposure have been described elsewhere.[3] Since the Army field equipment has been supplied in such great numbers and since it is being used by so many roentgenologists, it would seem appropriate to describe the protective features which have been provided.

PROTECTIVE FEATURES COMMON TO THE TWO ARMY ROENTGENOSCOPIC UNITS (FIG. 1)

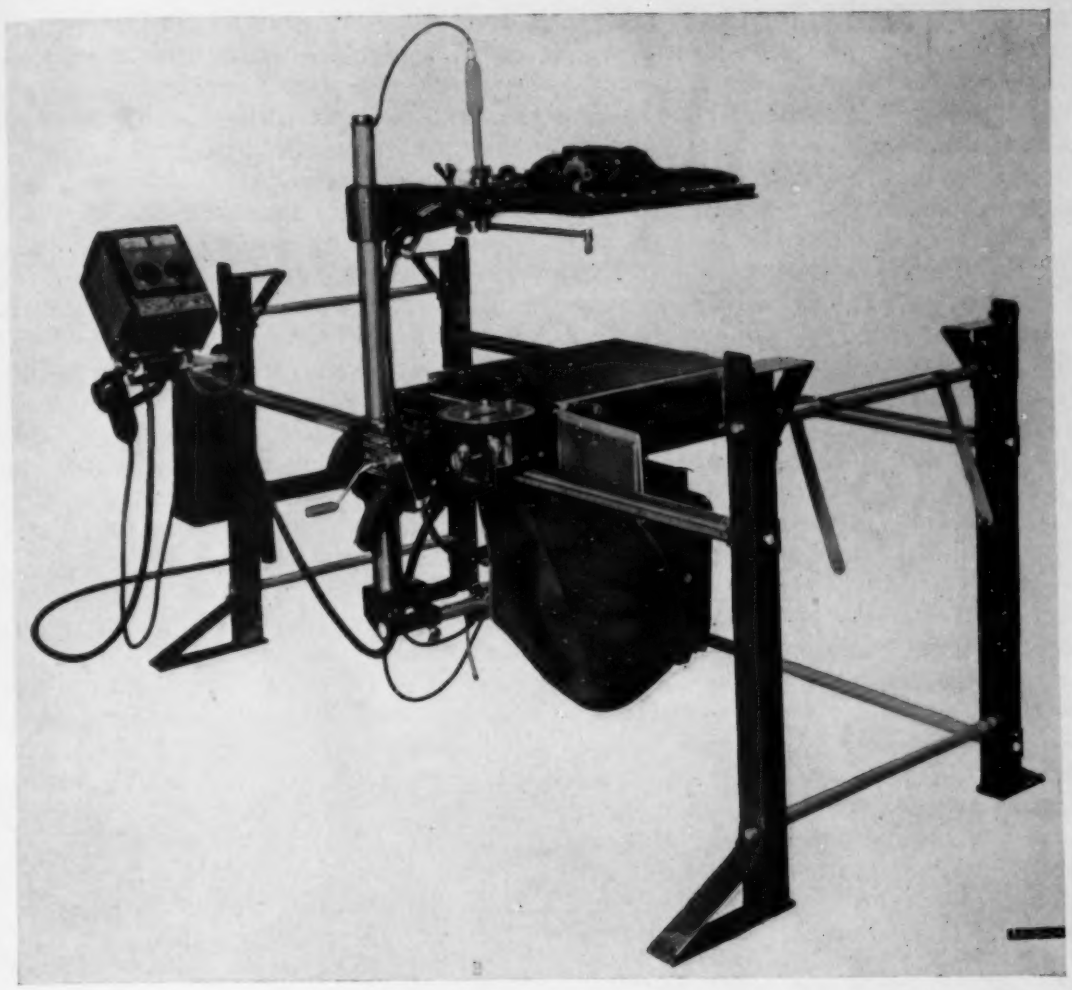
1. For roentgenoscopy, there is a fixed focal-roentgenoscopic screen alignment and distance (66 cm.). This feature serves to obviate mal-alignments of the primary beam or changes in the coverage of it by the roentgenoscopic screen as might apply in case the roentgenoscopic screen were allowed to move independently in relation to the roentgen tube. Many have advocated the use of a bonnet type of roentgenoscope which might be carried on the head of the operator to permit conducting these activities in a lighted room. This plan, and others similar to it, were rejected for the very reason that they would incur too great a hazard of roentgen-ray exposure.

2. The area of the roentgenoscopic screen is 12 by 16 inches, providing a large roentgenoscopic field and therewith a large area of protection against secondary radiation from the patient. Many have recommended that in order to reduce the weight to a minimum and to facilitate the exchange of patients, the dimensions of the roentgenoscopic screen should be 10 by 10 inches, as used in the first World War. These advantages were sacrificed in favor of protection.

3. During foreign body localization, the skin surface can be marked by a special device[2] which can be manipulated *beneath* the roentgenoscopic screen but without exposing the hands of the operator to the primary beam. This is made possible because, with the method of localization which is used, the distance between the roentgenoscopic image and the skin surface is subtracted in the final adjustment of the depth scale, and it is not necessary to position the roentgenoscopic screen directly upon the skin surface. If the latter design were used, a perforation for admitting a



A



B

Fig. 1. The two United States Army roentgenoscopic units. *A*, the heavier but more versatile unit,[1] designed for all types of hospital installations where transportation is not too great a problem. *B*, the lighter weight unit, designed for usage for Air Service and for locations not easily accessible by motor transportation.

skin marker would be required, with resultant escape of secondary radiation as well as some primary radiation and exposure of the face of the operator, as occurred with equipment used in the first World War.

4. Stops are provided to limit the opening of the roentgenoscopic shutter so that the border of the primary beam is restricted to at least 1 inch within the protective limits of the roentgenoscopic screen (cf. features 1 and 5). Thus, even with the most careless operation of the shutter controls, it is not possible for any part of a primary beam to escape beyond the limits of the protection provided by the roentgenoscopic screen and its lead protective glass (protection equivalent to no less than 1.5 mm. lead).

5. The roentgenoscopic screen and the roentgen tube are mounted on a C-shaped support which is adjustable in the vertical plane, thus permitting variation of the focal skin distance and utilization of the greatest focal skin distance possible during localizations—and the least part-screen dis-

tance. This feature serves to minimize roentgen radiation exposure of the patient and concurrently to reduce secondary radiation from the tissues. It is of advantage to utilize this provision for it also provides for the optimum of visualization by improving contrast and sharpening detail.

6. Except for the portal for exit of the primary beam, the roentgen tube housing is impregnated with material possessing a protective equivalence of no less than 1.5 mm. lead.

7. Through the portal intended for the primary beam, the combined inherent filtration is equivalent to 0.5 mm. aluminum. This filtration consists of the wall of the insert tube (1.0 mm. pyrex glass), a thin layer of oil (1.5 mm.), a transparent bakelite wall (1.5 mm.) plus an added fixed filter of 0.25 mm. aluminum. Thus unnecessary soft radiation has been eliminated while retaining intensity sufficient for roentgenography.

8. For roentgenoscopy, in addition to the filter just described, there is a second fixed filter of 0.5 mm. aluminum. This filter is fixed into the housing of the roentgenoscopy shutters. Thus, the total filtration during roentgenoscopy is consistent with the stipulation contained in paragraph 2.03 of Handbook HB-20 as compiled by the Advisory Committee on X-ray Protection and as published by the National Bureau of Standards.

9. The shutter controls are contained in the vertical portion of the C-shaped supporting member, referred to above, at a liberal distance from the primary beam and the sources of secondary radiation. This feature serves to minimize the exposure incurred by the examiner's forearm, and moreover it lessens the tendency for him to lean closely toward the side of the patient, whereby he would receive more extensive exposures.

10. The method of foreign body localization is such that only three short exposures for alignments are required. The localization procedure can easily be accomplished within thirty to forty-five seconds whereby even with the very shortest focal skin distance (10 inches—allowing for a very heavy patient, a very old litter) and using 85 kv. (peak) and 5 ma., the dose at the skin of the patient would be approximately 15 roentgens. The reading of the depth scale and the calibration scale can be made only while the roentgen-ray exposure is interrupted, this feature being in contrast to so many methods which provide for reading of measurements with the assistance of fluorescence from the roentgenoscopic screen

11. An adjustable limiting resistance is incorporated into the control so that when the thumbswitch or footswitch is used (either being required for roentgenoscopy) the maximum milliamperage load can be limited to 5 ma. or any lesser value.

12. The fastest type of roentgenoscopic screen is provided, minimizing exposure requirements to the utmost.

13. The table top is a standard United States Army litter. It is constructed of materials of low atomic number—canvas and aluminum. The secondary roentgen radiation emitted from a litter type of table top is considerably less than that emitted from conventional table tops and thus this source of secondary radiation is relatively reduced.

14. A lead impregnated apron and a pair of lead impregnated gloves are part of the contents in the field chest which accommodates the control unit of the roentgen-ray machine. Thus, it is certain that at least one lead apron and one pair of gloves will be taken to every installation where the roentgen-ray machine unit is to be operated. The United States Army does not suggest; it *enforces* the wearing of a lead apron and lead gloves while using field roentgen-ray equipment. Samples of these items are tested at the Army School of Roentgenology and unless their quality is up to standard, including the requirement that a single thickness of either shall provide protection equivalence of no less than 0.5 mm. lead, these items are rejected. The supporting straps of the aprons provide for suspension from one shoulder to the oppo-

site hip—rather than from the neck—thus giving the maximum of comfort in the wearing of these otherwise cumbersome garments. The standard gloves have a length of 37 cm., which is somewhat longer than gloves commonly used in many clinics.

15. An auxiliary lead impregnated shield is supplied as a separate item. It can be adapted to either end and to either side of either of the two official table units. Thus, this item has an eight-way adaptation. It is carried as a separate item, as are the apron and gloves, for all three can be expected to deteriorate. The auxiliary shield is designed to protect the legs of the operator below the bottom of the lead rubber apron. With it the operator and attendants or observers are protected throughout the arc of greatest intensities of scattered radiation—considering the lateral and downward trajectories with respect to the roentgen tube and screen.[3]

16. Several types of instruction manuals are provided. They have been issued by the several manufacturers as well as by the Army. In particular, technical manual TM 8-275 includes a chapter dealing with roentgen radiation hazards. The possibilities of roentgen-ray injury are cited as well as the limitation of protection that can be expected.

RECIPIENT INTENSITIES OF STRAY RADIATION

It has been shown[3] that when apparatus such as the Army Field roentgen-ray equipment is used for horizontal roentgenoscopy, the distribution of stray radiation, above the table top, is essentially the same as with conventional roentgenoscopic equipment. Since the operator of Army equipment is required to wear a lead impregnated apron, it is only below this apparel that he could receive radiation in excess of that to which he might be subjected with conventional equipment.

There are three important components of radiation to be considered in the region below the lead impregnated apron: leakage of primary and stray radiation from within the tube housing itself; secondary radiation from the shutters and their housing, and secondary radiation from the patient. These have been discussed more fully in the preceding paper.[3] It is the function of the auxiliary lead impregnated shield (feature 15) to protect the knees, legs and feet of the operator from these three components. This shield in conjunction with the lower part of the lead impregnated apron serves in much the same way as do the metal side panels on a totally enclosed "heavy duty" roentgenoscopic table.

The data contained in Table 1 are representative values selected from extensive testings performed by the several observers. Measurements were made with the roentgen tube in the middle position of table width as well as in the far and near positions. The data here recorded are of maximum values in this respect. Moreover, they are based upon the outer limits of roent-

TABLE 1

IONIZATION MEASUREMENTS WITH THE STANDARD UNITED STATES ARMY FIELD TABLE UNIT

Roentgens per hour as measured at knee and foot positions for operator (apron not placed in position as it would be worn)

Observer	Glasser*	Picker†	Wintker‡	Present Authors
Size of phantom	25×25×25 cm.	25×25×25 cm.	20×31×21 cm.	20×31×21 cm.
Field at screen	25×25 cm.	25×25 cm.	25×25 cm.	20×20 cm.
Knee	0.048	—	0.023	0.020
Foot	0.048	0.036	0.008	0.020

* Values in this column are presented with the kind permission of Dr. Otto Glasser, Cleveland Clinic Foundation. The values otherwise tabulated were obtained subsequent to an improvement in the method of fixation of the auxiliary shield.

† Appreciation is expressed for the special interest by Mr. E. R. Goldfield and Mr. Tom Callaghan of the Picker X-ray Corporation in conducting independent testings from which this value was selected.

‡ First Lieutenant, Sanitary Corps, Department of Roentgenology, Army Medical School, Washington, D. C.

genoscopic factors—85 kv. (peak) and 5 ma. They are concerned with *continuous* exposures. It is estimated that, allowing for the exchange of patients, the marking and making of adjustments between exposures together with intermittent interruptions of common practice, actual energization of the equipment can be expected for approximately 25 per cent of the time. Thus two and one-half hours of continuous operation might be considered equivalent to a ten hour day of roentgenoscopic activity. It will be noted that if the exposure values given in the table were adjusted for a ten hour day (multiplying by the factor of 2.5) the summation values are well under the recognized tolerance dose. Similar low exposure intensities were found for the lighter weight unit.

DISCUSSION

The Subcommittee on Radiology* of the Committee on Surgery of the National Research Council, after hearing of the protection features, together with the analyses which have been made and seeing the equipment, have expressed themselves with the following resolution:

> Investigations have been made of the protection provided by the U. S. Army Field Apparatus. The Subcommittee on Radiology for the National Research Council is of the opinion that the protection is adequate if accessory equipment furnished is used according to instructions.

It has been pointed out that precautions have been taken to protect the operator's chest, trunk and lower extremities against exposures which many roentgenologists accept daily upon their arms and shoulders with complete unconcern. These exposures of the shoulders and arms may be several times the internationally accepted tolerance dose. Is it to be concluded that the standard includes a factor of safety sufficiently large so far as exposure to a limited portion of the body is concerned, to make us accept such exposures as safe? Geneticists have presented evidence which indicates maleffects to quantities of radiation considerably smaller than the tolerance dose, at least when exposing the reproductive organs. Yet so far as can be judged from the official statement of the tolerance dose, any portion of the body, large or small, requires the same protection as the whole body. For various reasons (e.g., pension claims, morale, etc.), the Army is compelled to adhere as closely as possible to official standards. This leads to complications where the standards are equivocal. In anticipation of future problems as far as our Government is concerned and considering the interest which has been manifested by the public as a whole, it would seem that radiologists and radiation physicists should strive for a more detailed specification of the tolerance dose; a definition of it with respect to exposure of the trunk, with respect to exposures of the extremities alone, or the whole body.

* The Subcommittee consisted of the following: Dr. A. C. Christie (Chairman), Dr. B. R. Kirklin, Dr. U. V. Portmann, Dr. W. E. Chamberlain and Dr. E. P. Pendergrass.

SUMMARY

1. A description of the protective features incorporated into both types of Army roentgenoscopic equipment is presented.

2. Sixteen features of design concerned with protection are described.

3. Ionization measurements of exposure concerned with parts of the body protected by a lead apron and the auxiliary lead protective shield are tabulated.

4. The resolution of the Subcommittee of Radiology of the National Research Council, expressing satisfaction with this equipment, is cited.

5. It is suggested that a more adequate definition of the tolerance dose be expressed with consideration of exposure of the trunk portions of the body, the extremities alone or the whole body.

REFERENCES

1. DE LORIMIER, A. A. Wartime military roentgenology. *Radiology*, 1941, *36*, 391–403.

2. DE LORIMIER, A. A. Foreign body localization as provided with the United States Army table

unit. Am. J. Roentgenol. & Rad. Therapy, 1942, *47*, 307–313.
3. White, T. N., Cowie, D. B., and de Lorimier, A. A. Radiation hazards during roentgenoscopy. Am. J. Roentgenol. & Rad. Therapy, May, 1943, *49*, 639–652.

DISCUSSION OF PAPERS BY WHITE, COWIE AND DE LORIMIER

Dr. Robert B. Taft, Charleston, S. C. Two years ago, before this Society, I had a little paper on stray radiation. Dr. Glasser, in the discussion of that paper, said I had presented absolutely nothing new except colored lantern slides, but he went on to say that it was a good paper because all papers on stray radiation are good papers as they make us more conscious of the dangers that we are running if we are not careful.

Colonel de Lorimier has presented some new material here: first of all, very careful tests all around roentgen tubes in operation, which, as far as I know, have not been accurately recorded in the past. He has not only done that, but he has given us a large amount of information on the sources of secondary radiation which one gets around a fluoroscope. I have gone over his figures very carefully and studied both of these papers, and in my opinion this table is a perfectly safe apparatus with which to work under any ordinary circumstances.

I definitely believe that any man doing roentgenoscopy ought to wear an apron. I think it is a simple form of protection which means more than anything that can be done to the machine. I believe a man is taking a very foolish chance not to wear an apron. I do, however, know of lots of good lead rubber aprons that are hanging up on a peg on a wall while the radiologist is doing his roentgenoscopic work. I am glad to say that the pendulum has swung in the right direction in regard to roentgen-ray protection and I am delighted to see papers of this kind presented. There is only one thing wrong about a presentation of this kind. It does not get to the right men. The members of the American Roentgen Ray Society know something about roentgen-ray protection. Where these papers ought to be given is back home in our local medical societies where men are fooling with small roentgen machines without knowing what they are doing.

I have only to quote briefly a paper of our esteemed colleague, Dr. Pfahler, from the *American Dental Journal* a number of years ago. Very briefly, if I remember the story, a physician and a dentist went out shooting. There was a minor accident. One of them got a small shot in his finger. They came back and proceeded to remove it fluoroscopically under the dental roentgenographic machine, as a result of which both of them had to have so many fingers amputated that the dentist had to quit doing dentistry and the surgeon had to give up surgery.

Those things go on happening and I know of many cases that have happened after Dr. Pfahler wrote that paper.

I think the manufacturers have done an excellent job in making tubes shock proof. They have done a reasonably good job in making tubes ray proof. They have, however, as I said, not made the tubes fool proof and I do not know of any roentgen machine which will not give a dangerous dose of radiation to a man who stands in the beam of it.

Major Theodore S. West, M.C., U. S. Army. Colonel de Lorimier and his associates have made a great contribution in this investigation of roentgen-ray hazards. I have been greatly interested in the matter of roentgen-ray protection for many years, and it is my belief that many of the younger roentgenologists do not fully appreciate the hidden dangers of the agent with which they work, and that they are inclined to expose themselves to an unsafe amount of radiation.

Those of us who had the advantage of Professor Shearer's teachings appreciate the dangers to ourselves and to our patients, and have a wholesome fear of roentgen rays, which does not seem to be shared by the younger men. Indeed, some of the older roentgenologists seem to be getting careless of themselves—if not of their patients.

I heartily agree with Dr. Taft that this work of Colonel de Lorimier's should be broadcast to the medical profession at large, and not be presented only to roentgenologists who are at least supposed to realize the dangers. Roentgenologic apparatus is now being purchased and used by an increasing number of physicians who have not had adequate training or instruction, and who do not appreciate the dangers.

Advertisements for apparatus seem rather to emphasize the innocuousness of the roentgen ray. I recall a picture in one of the recent journals showing the patient cozily snuggled in bed, the mobile roentgen unit in position, the kindly doc-

tor along side, and the beautiful nurse with her toe on the foot switch. No protective apron or gloves, not even a reasonable distance protecting anyone from the scattered radiation.

I recently visited the roentgen department of a fairly large hospital in which the control stand was in the same room with the roentgen table. No protective booth, not even a protective screen to shield the operator.

I have recently seen several cases of severe roentgen burns resulting from the use of the fluoroscope for guidance in setting fractures or extracting foreign bodies. The victims, in four of these cases, were physicians who "didn't realize the danger."

It seems to me that it is the responsibility of the radiological societies to make an attempt to educate the profession at large on this matter. Perhaps a brochure on the subject could be published by the combined societies, and, in cooperation with the manufacturers of roentgen-ray equipment, given to every purchaser of a roentgen-ray apparatus. This may be a big order, but I believe it is our job to see that some such work is done.

Dr. Lauriston S. Taylor, Washington, D. C. One of my main jobs for many years has been the study of roentgen-ray protection, and this paper dealing with radiation hazards during roentgenoscopy has been particularly gratifying to me because the authors have attacked a difficult protection problem and not become panicky in the process. I am probably one of the strongest believers in protection, yet I feel that there has been a tendency to become panicky and to over-protect to the point where the equipment is no longer usable or where the medical procedures cannot be carried out adequately. Perfect protection can, in my opinion, be obtained only by never turning on the roentgen tube.

I was particularly glad also to see the point brought out indicating the importance of scattered radiation from the patient's body. Many elaborate roentgen-ray protective installations have centered about the radiation which emanates from the tube, paying practically no attention to that which comes from the patient's body and from nearby metal surroundings, table tops and so on. As was very clearly pointed out a number of times, the bulk of the radiation does come from the patient and not from the tube proper.

Mr. Singer, in our laboratory, has been studying a number of pieces of new equipment for the Army. These have been what I believe Colonel de Lorimier describes as the heavy duty type of equipment. It has been our finding, in practically every case, that if you examine the radiation which comes from the roentgen tube, you will find evidence of leakage and your first reaction is to become very much upset and to tell the manufacturer he has to put more lead around the tube. However, in practically every case—I believe in every case—it is found that the simple sheet steel barriers which are put there for the purpose of electrical protection, or for mechanical strength are quite adequate to completely cut off the remainder of the radiation which does leak out of these tube housings. When I say completely cut off, I mean it reduces it to a level beyond which it would be foolish to go any further, because you are operating in an atmosphere of stray radiation no matter what you may do otherwise.

This matter of protection about the roentgen tube is viewed in this paper for the first time that I know of, in its proper light.

There is one other point which was considered in the course of the studies at Walter Reed Hospital. I have discussed these at considerable length with Dr. White and I am not sure whether or not they are going to mention this in the paper. In addition to the broad outlines which have been presented here, they have also studied specific small regions where more intense radiation might be obtained. For example the radiologist must keep his hand on the shut, ter controls for a considerable period of time. That is behind the barrier, or at one side of the barrier, I believe, and it is quite conceivable that stray radiation from the roentgen tube might expose that particular location to much stronger radiation than would be encountered at any of the normal positions of the body. In this particular case, as an example, they carried the investigation through and found that the radiation was or could be reduced to a safe level and then pronounced the equipment safe.

The authors are to be very strongly congratulated on the thoroughness with which this piece of work has been carried out.

Colonel de Lorimier (closing). I wish to thank the discussants and in particular Major West and also Dr. Taylor for their kind remarks and to pay a tribute to Dr. Scheele and Mr. Cowie and Dr. White for the excellent work that they are doing in going around the coun-

try and conducting testings of the same sort with respect to the various roentgenoscopic rooms. Dr. Taylor and Dr. Singer are concentrating on this matter of radiation hazards in their testing of field roentgen-ray equipment.

I wish to make one more remark. That has to do with a plea mentioned in the latter part of our second paper, in which I tried to emphasize the amount of radiation that is received by the shoulders and arms of the roentgenoscopist regardless of the type of equipment which he is using. In anticipation of future problems—I mean pension claims as far as our government is concerned—and considering the interest which has been manifested by the public as a whole, it would seem that radiologists and radiation-physicists should strive for a more detailed specification of the tolerance dose, a definition of it with respect to exposure to the trunk, with respect to exposure to the extremities alone, or with respect to exposure of the whole body.

STUDIES ON THE INDIRECT EFFECT OF ROENTGEN RAYS IN SINGLE AND PARABIOTIC MICE*

By W. A. BARNES, M.D., *and* O. B. FURTH, M.D.
From the Department of Pathology, Cornell University Medical College,
NEW YORK, NEW YORK
and
The Marine Biological Laboratories
WOODS HOLE, MASSACHUSETTS

A VAST literature has accumulated on the effect of irradiation on normal and malignant tissues since Heineke[13] in 1904 described the destructive changes occurring in lymph nodes, spleen, and bone marrow following irradiation by roentgen rays. He noted the occurrence of leukopenia and suggested that the diminution in circulating lymphocytes was referable to selective destruction of lymphoid tissue by roentgen rays. His observations have been confirmed by numerous workers,[10,21] and little of fundamental importance has been added. Opinions concerning the mechanism of the action of roentgen rays on living tissue can be considered under three headings: (a) direct effect on cells, (b) indirect effect, local and general; (c) combined direct and indirect effect.

Direct Effect. Numerous experimental studies have indicated that the most important action of roentgen rays on living tissue is the direct effect on cells, although there is no agreement concerning the mechanism.[8,9,33,34,36] This effect will not be considered in detail.

Indirect Local Effect. Many investigators are of the opinion that only by interaction of cells and tissue fluids surrounding the irradiated cells is the injurious effect of irradiation accomplished, e.g., production of secondary rays,[8,9,20] damage to endothelial linings of capillaries followed by proliferative changes,[29] alterations in permeability of cell membranes, or in the acid base equilibrium,[26] changes in the concentration of radio-ions,[11] etc.

Indirect General Effect. Many investigators believe that roentgen rays produce an effect in organisms even in parts not directly exposed to the rays.[cf.34] This indirect general effect has been attributed (*a*) to circulation of toxic substances[40,47] or more specifically to products of disintegration of proteins named necrohormones;[7] (*b*) to the action on the autonomic nervous sytem;[23,32] (*c*) to action on organs of internal secretion;[cf.46,19] (*d*) to changes in the chemical composition of blood;[16,19] (*e*) to changes in electrolytes,[35] etc.

Since the indirect general effect of roentgen rays is doubted by some investigators, and few experimental studies have been reported, we have reinvestigated the character and magnitude of changes produced in tissues of single and parabiotic animals exposed directly to roentgen rays or protected from them while other portions of the body were subjected to irradiation. A few investigators have studied the effect of roentgen rays on parabiotic animals, but these results have not been concordant. We shall describe first the changes in single animals. Observations on the effect of irradiation on the blood and blood forming tissues of parabiotic mice will then be presented.

Changes in the bone marrow of animals following exposure to roentgen rays have been described in numerous reports.[2,13,15,22,37,38,39,42,43,45] As early as 1905, Aubertin and Beaujard[3] described the unexposed bone marrow of irradiated rabbits as red and hyperplastic. Recently while our investigations were in progress, Hsü and Ma[15] studied changes in the exposed and unexposed bone marrow, spleen, and lymph nodes of rats whose right hind limbs were irradiated with a daily dose of 125 r for a total of 1,000, 2,500 or 5,000 r. Changes in the exposed and non-exposed bone marrow were similar, i.e., increase of fat cells, hyperplasia of erythrocytes and hypoplasia of myeloid cells. The changes in

* This investigation has been supported by the International Cancer Research Foundation, The Lady Tata Memorial Trust, and The Anna Fuller Fund.

the unexposed marrow did not vary conspicuously with the quantity of radiation and were notably less than in the directly irradiated marrow. In the spleen directly irradiated, the lymph follicles were reduced in size, there were islands of erythroblasts in the red pulp and the number of phagocytes increased with increase in the dose of roentgen rays. In unexposed lymph nodes there was reduction in the number and size of the lymph follicles in the cortex, increase in size of the sinusoids in the medulla, and increase of plasma cells. The authors consider the changes in the spleen, lymph nodes and non-irradiated marrow as "compensatory hyperplasia." Akaiwa and Takeshima[1] studied the effect of irradiation on popliteal lymph nodes of rabbits, of which one knee was exposed to ⅓, ½, 1 or 2 "s. u. d.," and the other used as "control." Sections were made at from thirty minutes to three weeks after irradiation. As early as one hour after exposure to ⅓ "s. u. d.," disintegration of lymphocytes in the lymph follicles began, reaching a maximum in from two to six hours. From this time on, marked phagocytosis was noted, the monocytes taking up the chromatin particles of the decomposed nuclei. This activity almost ceased after forty-eight hours. Regeneration of the lymphoid tissue then occurred and by the seventh day the node was normal except for slight increase in connective tissue. In the non-irradiated lymph node there was slight increase in the number of mitotic figures after one hour. At two hours there was disintegration of lymphocytes. Phagocytosis was present at twenty-four hours and fragments of cells were present to the tenth day. There was return to normal only after two weeks. Similar changes occurred with larger doses except that the end-result was fibrosis of both irradiated and non-irradiated lymph nodes.

There have been numerous studies concerning the effect of irradiation on cells of the circulating blood of single animals. It is certain that leukocytes and particularly lymphocytes are profoundly damaged by roentgen rays[5,17,18,28,41,44] although opinions differ as to the mechanism of leukopenia.

A few investigators have studied the effect of roentgen rays in parabiotic animals. The results have not been uniform.

While Zacherl[46] and Zwerg,[47] working with parabiotic rats, found leukopenia in both the irradiated and shielded animal, Woenckhaus[44] described leukopenia in the irradiated parabiotic rat and leukocytosis in the shielded parabiont. Behne[4] found leukopenia in both the irradiated and shielded parabiotic guinea pig twenty-four hours after irradiation; and whereas the irradiated animal showed progressive leukopenia until its death five or six days after irradiation, the shielded parabiont showed an "enormous" leukocytosis two days after irradiation.

The contradictory results of these earlier studies on parabiotic animals can be explained as follows: The number of parabiotic pairs used is often not stated; in many instances the results in one pair only are analyzed. The number of leukocytes of small laboratory animals varies greatly under physiological conditions, and only a very marked drop or rise, if consistently found, should be considered significant. The quantities of roentgen rays used are frequently not stated, reference being made to small, medium or lethal doses. The investigations were concerned with changes in blood counts without examination of the blood forming organs, and the relation of different doses of roentgen rays to the blood changes produced was not studied.

MATERIALS AND METHODS

The animals used came from several stocks of mice inbred in this laboratory for many years. In each experiment mice of the same stock, of the same age, and in many cases litter mates, were used. In animals in which only a part of the body was irradiated, the remainder was protected by from 3 to 6 mm. of lead and adequate precautions were taken against scattered rays.

For experiments on single animals the factors of irradiation were usually 200 kv., 15 ma., 25 cm., 3 mm. Al, and 320 r per minute. In several experiments the factors were 200 kv., 15 ma., 50 cm., 1 mm. Cu—1 mm. Al, and 50 r per minute.

In the experiments on parabiotic twins, 2 of 4 mice in each group were joined in parabiosis by the method of Sauerbruch as modified by Bunster and Meyer[6] with changes previously described.[12] Two to four weeks after operation all 4 mice were tied to a wire frame, and 1 of the

parabiotic and 1 of the control mice were irradiated over the entire body, while the other parabiont and single mouse were completely shielded from the rays. In one experiment (Twins No. 294 and No. 298 irradiated with 3,200 r) the mice were irradiated while under nembutal anesthesia and were not tied. In each experiment the number of leukocytes of parabionts and of single control mice was determined at two to three day intervals several times before, and from two to fifty days after irradiation. Blood was obtained from the tail vein, and specially designed small diluting pipettes were used permitting the accurate withdrawal of a small quantity of blood (approximately 0.04 cc.). Differential counts were made on smears stained with Wright's and Giemsa's solutions. Two hundred cells were counted except when the total number of leukocytes per cubic millimeter was less than 800 when fewer cells were counted or differential counts were omitted.

The physical factors of irradiation of parabiotic mice were as follows: 200 kv., 15 ma., 3 mm. Al, 25 cm., 320 r per minute. In Twins No. 149, 195, 300, 301, 302, 303 the physical factors were 198 kv., 25 ma., 68 cm., 94 r per minute. The mice died or were killed at intervals from one to fifty days following exposure. If one parabiont died, its twin and control mice were immediately killed.

To observe indirect effects of irradiation sections were taken from organs most distant from the site of irradiation, e.g., bone marrow from the left femur of the left mouse if the right member of a parabiotic pair was irradiated. Tissues were fixed in Bouin's solution and sections stained with hematoxylin and eosin.

OBSERVATIONS ON SINGLE ANIMALS

Bone Marrow

Mice. 800 r. Seventeen mice were exposed to 800 r over the entire body except the right leg. One or 2 mice were killed on each of the days after irradiation indicated below, together with a total of 6 non-irradiated control mice of the same stock and age. Reduction in the size of the spleen and lymphoid tissue of the irradiated mice was noted as recorded by other investigators. The histological changes in the irradiated and non-irradiated femoral marrow are indicated in Table 1.

The direct effects on bone marrow of irradiation with 800 r may be summarized as follows: hyperemia beginning within twenty-four hours and continuing for about ten days; decrease in the total number of hematopoietic cells, most conspicuous from the third to the fifth days; regeneration beginning on the sixth or seventh day, approaching completion by the eleventh or twelfth day, and characterized by increased number of megakaryocytes from the tenth to the twelfth days.

The indirect effects were as follows: slight hyperemia, present during the first two days; no reduction in the total number of nucleated cells; slight increase of polymorphonuclear leukocytes during the first two days, and slight myeloid hyperplasia with increased numbers of megakaryocytes from the ninth to the twelfth days.

2,000 r. In attempts to produce more conspicuous changes in non-exposed bone marrow of irradiated animals, 6 mice were irradiated with a large single dose (2,000 r) of roentgen rays over the entire body except one leg. The changes in the femoral marrow after irradiation were as follows:

One Day. Direct Effect. There is conspicuous dilatation of vessels with moderate decrease in total number of hematopoietic cells, but metamyelocytes, polymorphonuclears and megakaryocytes are numerous. *Indirect Effect.* There is slight dilatation of vessels, but no decrease in the number of cells.

Three Days. Direct Effect. Vascular dilatation is extreme and very few hematopoietic cells persist. There are several megakaryocytes. *Indirect Effect.* As in the preceding mouse.

Four Days. Direct Effect. As at three days but with only occasional megakaryocytes. *Indirect Effect.* Slightly more capillary dilatation than in the preceding mouse.

Five Days. Direct Effect. Almost no hematopoietic elements remain. *Indirect Effect.* As on the fourth day after irradiation.

Seven Days. Direct Effect. Conspicuous vascular dilatation with several foci of regenerating cells among which are numerous metamyelocytes. *Indirect Effect.* Apparently normal bone marrow with slightly increased number of megakaryocytes and erythrogenic foci.

TABLE I

CHANGES IN EXPOSED AND NON-EXPOSED BONE MARROW OF MICE IRRADIATED WITH 800 r

Irradiation		Changes in Bone Marrow			
Days after	Type	Capillary Dilatation	Total Number of Cells	Polymorphonuclears	Megakaryocytes
1	Direct	++	<+	++	o
	Indirect	+	o	+	o
2	Direct	+++	<++	++	o
	Indirect	+	o	+	o
3	Direct	++++	<++++	<++++	<++
	Indirect	±	o	o	o
4	Direct	++++	++++	++++	<+++
	Indirect	o	o	o	o
5	Direct	++++	<++++	<++++	<++++
	Indirect	o	o	o	o
6	Direct	++++	<+++	<++++	<++++
	Indirect	o	o	o	o
7	Direct	+++	<+++	<++++	<++++
	Indirect	o	o	o	o
8	Direct	+++	<++	<++++	<+++
	Indirect	o	o	o	o
9	Direct	+++	<++	<+++	<+++
	Indirect	o	+	±	++
10	Direct	+	<+	<+	o
	Indirect	o	+	±	++
11	Direct	o	+	o	+
	Indirect	o	+	±	++
12	Direct	o	+	o	±
	Indirect	o	+	o	+

o = no effect.
± = questionable.
+ = slight.
++ = moderate.
+++ = extensive.
++++ = very extensive.
< = decrease.

6,000 r. In further attempts to produce more conspicuous changes in non-exposed bone marrow of irradiated animals, 9 mice were exposed to 6,000 r over the upper or the lower half of the body. Three normal mice were studied as controls. The changes in marrow exposed to and shielded from the roentgen rays were as follows:

One Day. Direct Effect. There is moderate dilatation of capillaries, and conspicuous decrease in the number of hematopoietic cells with slight increase in polymorphonuclears. Slight fragmentation of nuclei is evident. *Indirect Effect.* There is slight hyperemia and a questionable slight decrease in the total number of hematopoietic elements. Multilobed polymorphonuclear leukocytes are increased in number.

Three Days. Direct Effect. There is very con-

spicuous dilatation of capillaries, and almost complete aplasia. A few megakaryocytes persist. *Indirect Effect.* There is very slight hyperemia. In 1 mouse there is questionable slight decrease in the total number of hematopoietic cells; in 2 other mice there is no obvious deviation from normal.

Six Days. Direct Effect. There is very conspicuous capillary dilatation and almost complete absence of hematopoietic cells of the marrow. *Indirect Effect.* No abnormalities are noted.

Rabbits. 1,500 r. The effect on bone marrow of irradiation with 1,500 r of the upper two-fifths of the bodies of rabbits is shown in Table II. In the marrow of the humerus exposed directly to roentgen rays pyknosis was noted as early as two and one-half hours after irradiation with subsequent marked destructive changes. In the femoral marrow not directly irradiated, there was questionable hyperemia and pyknosis after two and one-half hours; after six hours pyknosis was more evident. Hyperemia increased until the second day when increased numbers of polymorphonuclear leukocytes were noted in the non-exposed marrow.

Comment. The effects produced in exposed and non-exposed bone marrow of mice receiving 800, 2,000, or 6,000 r to the entire body except one leg varied but little qualitatively. The larger the dose, the earlier noted was the decrease of hematopoietic cells in the directly irradiated marrow. There was capillary dilatation in the unexposed marrow from three to five days after irradiation, but no decrease in the number of hematopoietic cells except perhaps one to three days after 6,000 r. These experiments show that in mice, after a single exposure (with one leg shielded) to as much as 6,000 r, there are no conspicuous destructive effects in the non-exposed marrow after from three to five days. Six hours following irradiation with 1,400 r of two-fifths of the bodies of rabbits, pyknosis was noted in non-exposed bone marrow with no destructive changes thereafter.

Lymph Nodes

Lymphocytes have long been recognized as the cells most susceptible to direct ef-

TABLE II

EFFECT OF IRRADIATION OF UPPER TWO-FIFTHS OF BODIES OF RABBITS WITH 1,500 r

Rabbit		Thymus							Cervical Node							Marrow of Humerus							Spleen							Mesenteric Node							Popliteal Node							Marrow of Femur						
Number	Time killed after irradiation	Hyperemia	Lymphocytes	Pyknosis	Fragmentation	Mononuclears	Fibrosis	Hyperemia	Lymphocytes	Pyknosis	Fragmentation	Mononuclears	Polymorphonuclears	Hyperemia	Total cells	Pyknosis	Fragmentation	Polymorphonuclears	Hyperemia	Lymphocytes	Pyknosis	Fragmentation	Mononuclears	Polymorphonuclears	Fibrosis	Hyperemia	Lymphocytes	Pyknosis	Fragmentation	Mononuclears	Polymorphonuclears	Hyperemia	Lymphocytes	Pyknosis	Fragmentation	Mononuclears	Polymorphonuclears	Hyperemia	Total cells	Pyknosis	Fragmentation	Polymorphonuclears
1	24 hr.	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	○	○	ZZ	○	○	ZZ	○	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	○
2	6 hr.	±	ZZ	○	○	ZZ	○	±	ZZ	○	○	ZZ	○	±	ZZ	○	○	○	±	ZZ	○	○	ZZ	○	○	±	ZZ	○	○	ZZ	○	±	ZZ	○	○	ZZ	○	±	ZZ	○	○	○
3	12 hr.	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	○	○	ZZ	○	○	ZZ	○	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	○
4	1 da.	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	○	○	ZZ	○	○	ZZ	○	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	○
5	2 da.	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	○	○	ZZ	○	○	ZZ	○	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	○
6	4 da.	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	○	○	ZZ	○	○	ZZ	○	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	○
7	8 da.	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	○	○	ZZ	○	○	ZZ	○	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	ZZ	○	○	○

N = normal ○ = none ± = questionable + = slight 2+ = moderate 3+ = extensive 4+ = very extensive < = decrease

fect of roentgen rays and, as the following observations show, they are also susceptible to an indirect effect.

Lymph nodes from the neck and abdomen of 9 mice which had received 6,000 r to either the upper or lower half of the body were examined. The significant changes several hours after irradiation, slight in the shielded and marked in the exposed nodes, were as follows: pyknosis and fragmentation of the nuclei of lymphocytes, especially in the germinal centers after a few hours; hyperplasia of mononuclears with phagocytosis of cell fragments after twenty-four hours and removal of cellular débris during the next two days. After three days, the number of lymphocytes remained reduced in the exposed nodes.

Two adult rats were subjected to biopsy of right inguinal and axillary lymph nodes. The following day 6,000 r was administered to the upper half of the body of 1 rat and to the lower half of the body of the other, and eight hours later the left inguinal and axillary nodes were removed. The nodes directly exposed to roentgen rays showed extreme fragmentation of the nuclei of lymphocytes and many of the fragments were within mononuclear cells. The shielded nodes likewise contained intracellular and extracellular nuclear fragments, although conspicuously fewer than in the nodes exposed to direct irradiation.

As early as two and one-half hours after irradiation with 1,500 r of the upper two-fifths of the bodies of rabbits there was pyknosis and fragmentation in non-exposed spleens and mesenteric lymph nodes. Changes in non-exposed popliteal nodes were less conspicuous (Table II).

In 2 rabbits exposure of a leg to 2,560 or 3,200 r was followed in six hours by slight but definite pyknosis and fragmentation of nuclei in non-exposed popliteal nodes (Table III). Eight hours after the lower half of the body was irradiated with 3,200 r similar but more conspicuous changes occurred in shielded cervical, axillary and submandibular lymph nodes. The lymph nodes directly exposed to roentgen rays were extensively damaged. Although as much as 7,280 r was given to the ear of a rabbit pyknosis or fragmentation of nuclei was not observed seven hours later in an iliac lymph node (Table III).

TABLE III

EFFECT OF DIRECT AND INDIRECT IRRADIATION ON LYMPH NODES OF RABBITS

Part Irradiated	Dose of Roentgen Rays	Time of Examination after Irradiation	Fragmentation and Pyknosis in Lymph Node	
			Exposed	Shielded
	(r)	(hr.)		
Left leg	2560	6	+++	±
23 days later				
Lower half of body	3200	8	+++	++
Left leg	3000	6	+++	++±
Ear	7280	7	—	o

Scattered radiation might be held responsible for the changes occurring in non-exposed lymph nodes in animals as small as mice but the experiments on rats and rabbits eliminate this possible criticism.

Specificity of Changes in Shielded Organs of Irradiated Animals

Are the changes—hyperemia, slight increase of polymorphonuclear leukocytes in the bone marrow, and fragmentation and pyknosis of nuclei in the lymph nodes—specific indirect effects of irradiation, or non-specific? A study of the literature indicates

that similar degenerative changes can be produced by burns,[30, 43] heat, cold, electric current, and many chemicals and that there is little if any difference between the histological changes following irradiation and those induced by other means[cf. 25] A few experiments of our own confirm this observation.

Mice under nembutal anesthesia were burned by actual cautery over the abdomen and chest. They were killed from six to twenty-four hours later. The lymph nodes and bone marrow of these mice showed changes that were indistinguishable from those observed in these organs following indirect irradiation. The lymph nodes of 2 mice dying of iodoacetic acid poisoning also showed similar changes.

TABLE IV

CHANGES IN THE BLOOD FORMING ORGANS OF PARABIOTIC MICE FOLLOWING IRRADIATION WITH 800 r OF ONE PARABIONT

No. of Twin	Mouse Examined	Days after Irradiation Killed or Died	Macroscopic		Microscopic				
			Size		Bone marrow		Spleen		
			Lymph nodes reduced	Spleen (mm.)	Hyperemia	Reduction in No. of cells	Hyperemia	Reduction in No. of cells	Erythrogenesis
300	X single	1	+	13×4	++	++	+++	+	o
	X twin		o	12×3	+++	+	+	++	o
	C twin		o	12×3	+	o	o	o	o
	C single		+	18×5	o	o	o	o	+++
237	X single	3	++	11×2	++++	++++	+++	++	o
	X twin		+	12×2	++++	+++	+++	++	o
	C twin		o	20×4	+	o	o	+	+++
	C single		o	15×3	o	o	o	o	o
303	X single	3	+	11×3	++++	++++	+++	++	o
	X twin		+	12×3	++++	+++	o	o	+
	C twin		o	10×3	++	+	o	o	+
	C single		o	13×4	o	o	+	o	o
302	X single	5	+	12×3	++++	++++	++	++	o
	X twin		o	10×3	++++	++++	+	o	o
	C twin		o	18×4	o	o	+	o	++
	C single		o	16×4	o	o	o	o	o
238	X single	7	++	8×1	++++	++++	+++	+++	o
	X twin		+	10×2	+++	+++	++	++	+++
	C twin		o	11×3	++	o	o	o	++
	C single		o	15×5	o	o	o	o	+++
195	X single	10	o	10×2	+++	++++	+	o	o
	X twin		o	13×3	++	++	o	o	o
	C twin		o	11×2	+	+	+	o	o
	C single		o	15×5	o	o	++	o	o
301	X single	11	o	20×5	+	++	o	o	+++
	X twin		o	14×3	++	+++	o	o	+++
	C twin		o	20×4	o	o	o	o	++
	C single		o	18×4	o	o	o	o	+

X = irradiated.
C = non-irradiated.

OBSERVATIONS ON PARABIOTIC MICE

Effect of Varying Doses of Roentgen Rays on the Blood Forming Organs

800 r. The blood forming organs of 7 pairs of parabiotic mice were examined from one to eleven days after irradiation with 800 r of 1 member of each pair. At the same time the organs of 1 irradiated and 1 non-irradiated single control mouse were examined. Changes in spleen, lymph nodes and bone marrow are summarized in Table IV.

3,200 r. In order to determine whether larger doses of roentgen rays would produce significant effects in the non-irradiated member of a parabiotic pair, 1 member of each of 2 parabiotic twins was exposed to 3,200 r. One single mouse was similarly irradiated at the same time. One set of twins was examined four days and the other set six days after irradiation. The outstanding findings are shown in Table V.

TABLE V

CHANGES IN THE BLOOD FORMING ORGANS OF PARABIOTIC MICE AFTER IRRADIATION OF ONE PARABIONT WITH 3,200 r

No. of Twin	Mouse Examined	Days after Irradiation Killed or Died	Bone Marrow		Spleen	
			Hyperemia	Reduction in No. of cells	Erythropoiesis	Reduction in No. of cells
299	X twin	4	++++	++++	o	++++
	C twin		+	o	+++	o
298	X single	6	+++	++++	o	++++
	X twin		+++	++++	o	+++
	C twin		+	o	o	+
	C single		±	o	±	o

X = irradiated. C = non-irradiated.

This experiment shows that following irradiation with 800 r the pathological changes occurring in the blood forming tissues of irradiated mice in parabiosis with non-irradiated mice are slightly less than those occurring in single mice similarly irradiated. There is slightly less reduction in the total number of hematopoietic cells in the marrow in the irrradiated parabiont. Hyperemia and decreased cellularity in the spleen are less conspicuous in the irradiated parabiont than in the irradiated single control. In the non-irradiated parabiont evidence of damage to hematopoietic tissue is minimal. While there may be slight hyperemia in the bone marrow, decrease in the number of hematopoietic cells does not occur. There are no destructive changes in the spleen; however, that the non-irradiated parabiont is affected by irradiation of its twin is suggested by increased erythropoiesis in the spleen of 2 non-irradiated parabionts. There was severe damage to the spleen and bone marrow of the single irradiated mouse and of the irradiated twins; whereas, in the non-irradiated parabionts there was only slight hyperemia of the bone marrow, and, in 1, conspicuous erythropoiesis in the spleen.

6,000 r. In a third group of parabiotic twins, the early changes produced by a very large dose of roentgen rays were studied. Six thousand roentgens were given to 1 parabiont with the other shielded. One set was killed six hours and another seventy-two hours after irradiation. The results are shown in Table VI.

Seven hours after irradiation the spleen of the irradiated parabiont showed marked hyperemia, extensive fragmentation of nuclei of the lymphoid cells, an increase of polymorphonuclear leukocytes, with a definite decrease of

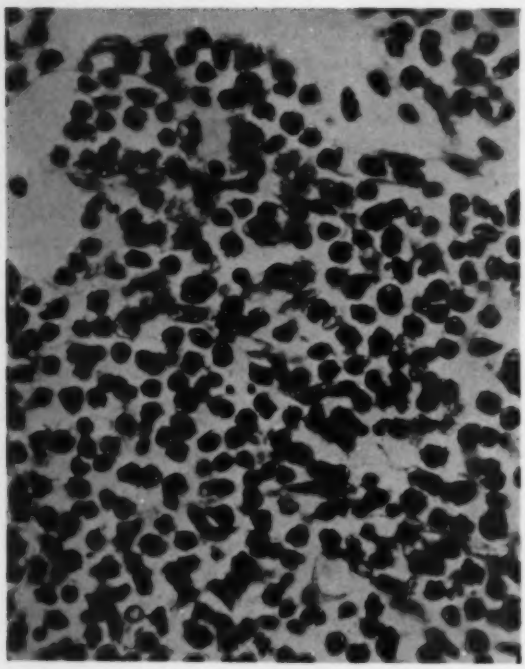


FIG. 1. The tissues illustrated in Figures 1, 2, 3 and 4 were fixed in Bouin's solution. The sections were stained with hematoxylin and eosin. Magnification are approximately 750×.

Cervical lymph node of control mouse.

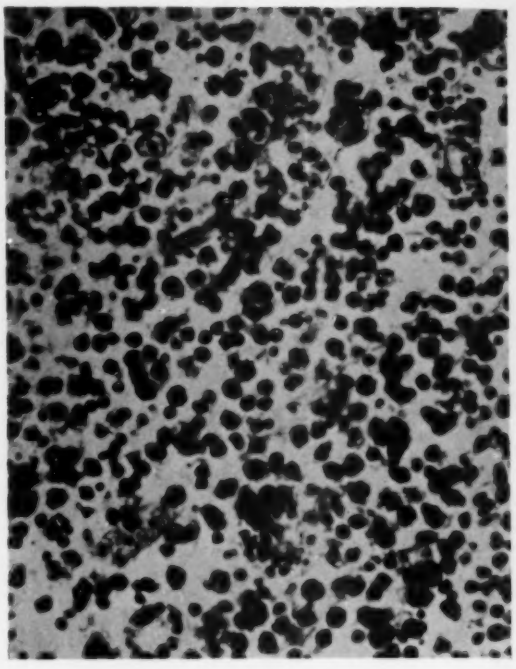


FIG. 2. Cervical lymph node of mouse seven hours after irradiation of upper third of body with 3,200 r. Conspicuous pyknosis and fragmentation are evident.

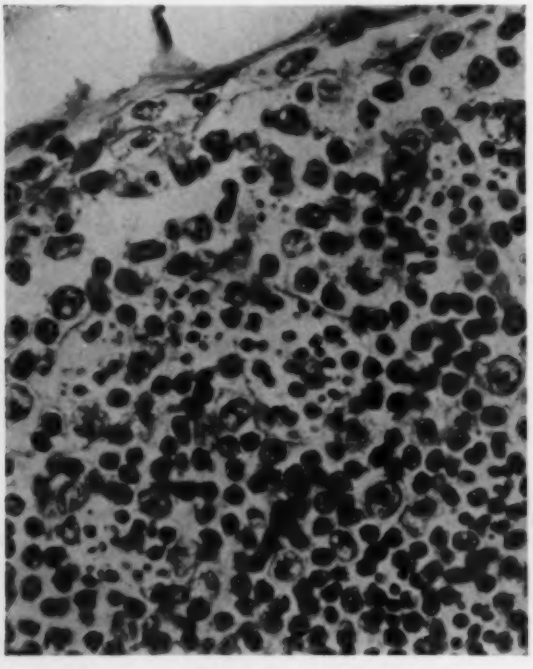


Fig. 3

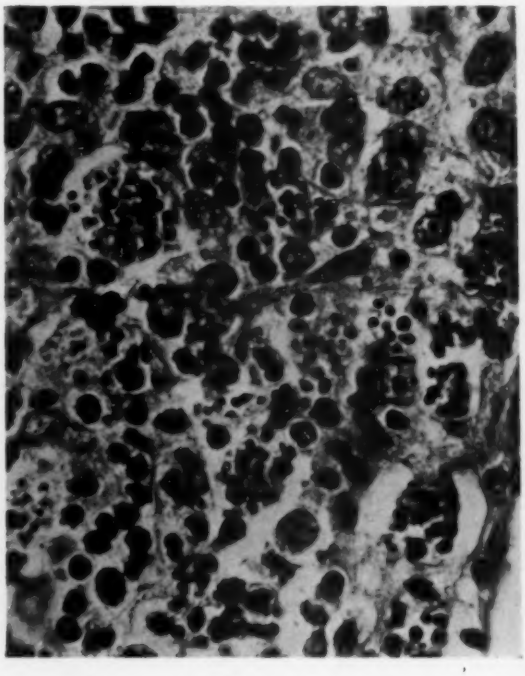


Fig. 4

FIG. 3 and 4. Cervical lymph nodes of mice seven hours after irradiation of lower third of body with 7,000 r (Fig. 3) and 3,200 r (Fig. 4). There is fragmentation of lymphoid cells with phagocytosis by mononuclear cells.

lymphoid elements. Fragmentation of nuclei was also marked in thymus and lymph nodes and only slight, but definite, in the bone marrow. The non-irradiated parabiont showed similar lesions, but to a lesser degree. In the bone marrow the only change was an increase of polymorphonuclear leukocytes.

In the parabionts examined seventy-two hours after irradiation the irradiated member showed marked hyperemia of lymph nodes and conspicuous decrease of cellular elements of bone marrow, while the nonirradiated parabiont showed an increase of polymorphonuclear cells in the bone marrow.

as the result of injury to hematopoietic organs, by Helber and Linser[14] as the result of direct injury to circulating blood cells and secondary changes in the blood forming organs due to circulating toxic substances.

Single Mice

It seemed desirable to establish the effect of varying doses of roentgen rays on the leukocyte counts of single mice so that the degree of change in the leukocyte levels of non-exposed members of irradiated parabiotic twins could be correlated with the dose required to produce similar changes in single mice.

Thirty-seven single mice were exposed over the entire body to doses of roentgen rays varying from 100 to 1,000 r. Leukocyte counts were made on the first, third, sixth, tenth, and in many animals on subsequent days after irradiation.

Graph 1 shows that the number of leukocytes in the circulating blood decreases in direct proportion to the dose employed. With larger doses the drop in leukocytes is evident one day after irradiation and reaches its maximum approximately six days after exposure with a gradual return to normal or above normal if the animals survive.

Parabiotic Mice

The effect of varying doses of roentgen rays on the number of leukocytes in the circulating blood was studied in 12 sets of parabiotic mice and 24 additional single controls. In each experiment 1 parabiont and 1 single mouse were irradiated with

TABLE VI

CHANGES IN THE BLOOD FORMING ORGANS AND THYMUS OF PARABIOTIC MICE AFTER IRRADIATION OF ONE PARABIONT WITH 6,000 r

No. of Twin	Mouse Examined	Hours after Irradiation Killed or Died	Thymus		Lymph Node			Spleen				Bone Marrow			
			Hyperemia	Fragmentation	Reduction in No. of cells	Fragmentation	Pyknosis	Hyperemia	Reduction in No. of cells	Fragmentation	Polymorphonuclears	Hyperemia	Reduction in No. of cells	Polymorphonuclears	Fragmentation
289	X twin	7	o	4+	+	3+	3+	2+–3+	+–2+	4+	4+	2+	o	+–2+	+–2+
	C twin		±	3+–4+	o	3+–4+	+	2+	+	2+–3+	3+	+	o	2+	o
288	X twin	72	o	o	3+	o						4+	4+	o	o
	C twin		o	o	±	±	o		Not examined			o	o	2+	o

X = irradiated.
C = non-irradiated

Comment. The changes occurring in the blood forming organs of a parabiont directly exposed to 800, 3,200 or 6,000 r are similar but quantitatively less than those occurring in a single mouse similarly irradiated. After irradiation of its twin with 800 or 3,200 r the non-irradiated parabiont shows no destructive changes in the blood forming organs one to eleven days later. However, seven hours after its twin received 6,000 r the non-irradiated parabiont showed pyknosis and fragmentation of nuclei of lymphoid cells. In spite of the initial damage the non-irradiated mouse recovered almost completely within three days, whereas the irradiated twin shows persistent damage consisting of aplasia of bone marrow and marked decrease of cellular elements of spleen and lymph nodes.

EFFECT OF VARYING DOSES OF ROENTGEN RAYS ON THE NUMBER OF LEUKOCYTES IN THE BLOOD OF SINGLE AND PARABIOTIC MICE

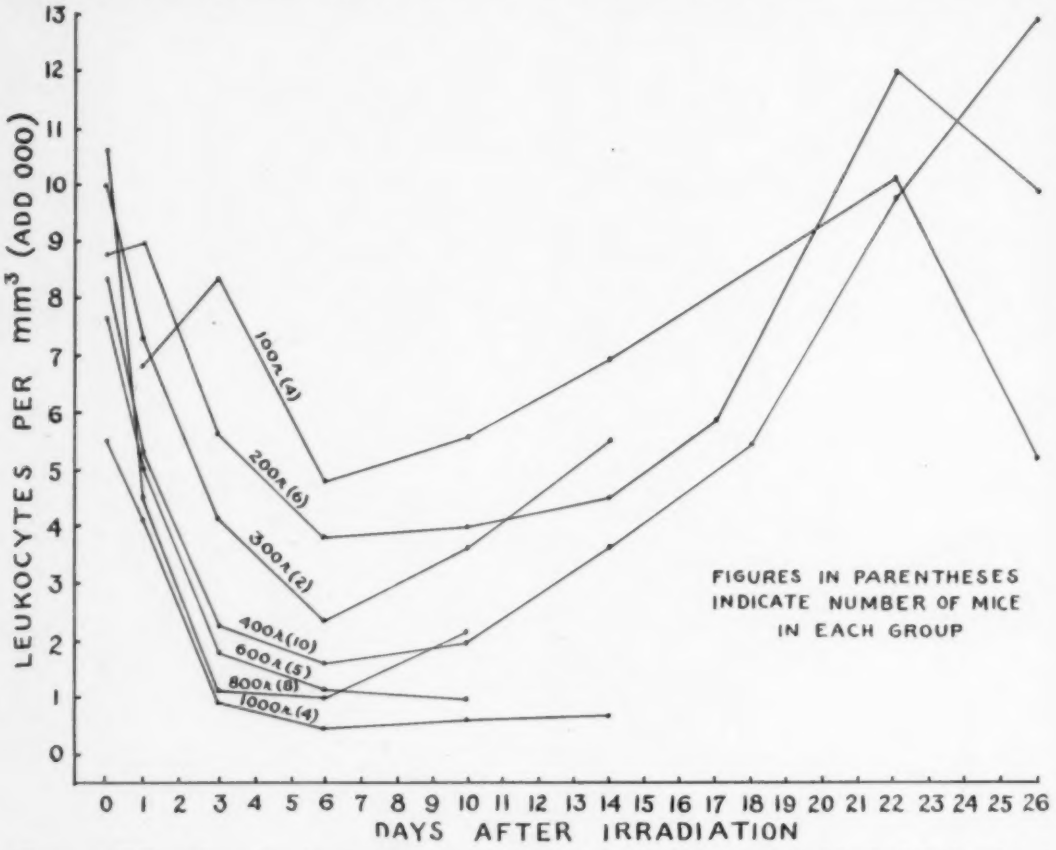
Marked decrease of leukocytes in circulating blood was explained by Heineke[13]

doses varying between 400 and 1,000 r.

400 or 450 r. Three sets of parabiotic twins (No. 9, 11, 13) and 6 single mice were studied. One parabiont of each pair and 3 single mice received 450 r. Twin No. 13 and 1 single mouse received an additional 400 r one month after the first irradiation.

Graph II shows that the average number of leukocytes after irradiation with 400 or 450 r was decreased very markedly in the single irradiated mouse, much less in the irradiated parabiont, and not at all in the non-irradiated parabiont. Parabiotic union with a non-irradiated mouse prevented conspicuous depression of the leukocyte level of the irradiated parabiont.

800 r. In seven experiments 1 parabiotic and 1 single mouse were exposed to 800 r, while the other parabiont and another single mouse were shielded. One parabiont of Twin No. 149 received an additional 800 r sixteen days later. Graph III shows that there is a greater decrease in the number of leukocytes in the single mice irradiated with 800 r than in the twin irradiated with the same dose. Return of the leukocyte level toward normal is evident after ten days in the irradiated parabiont but not in the irradiated single mouse. The non-irradiated parabiont shows slight leukopenia, which was not evident in the parabiont whose twin received only 450 r (Graph II).

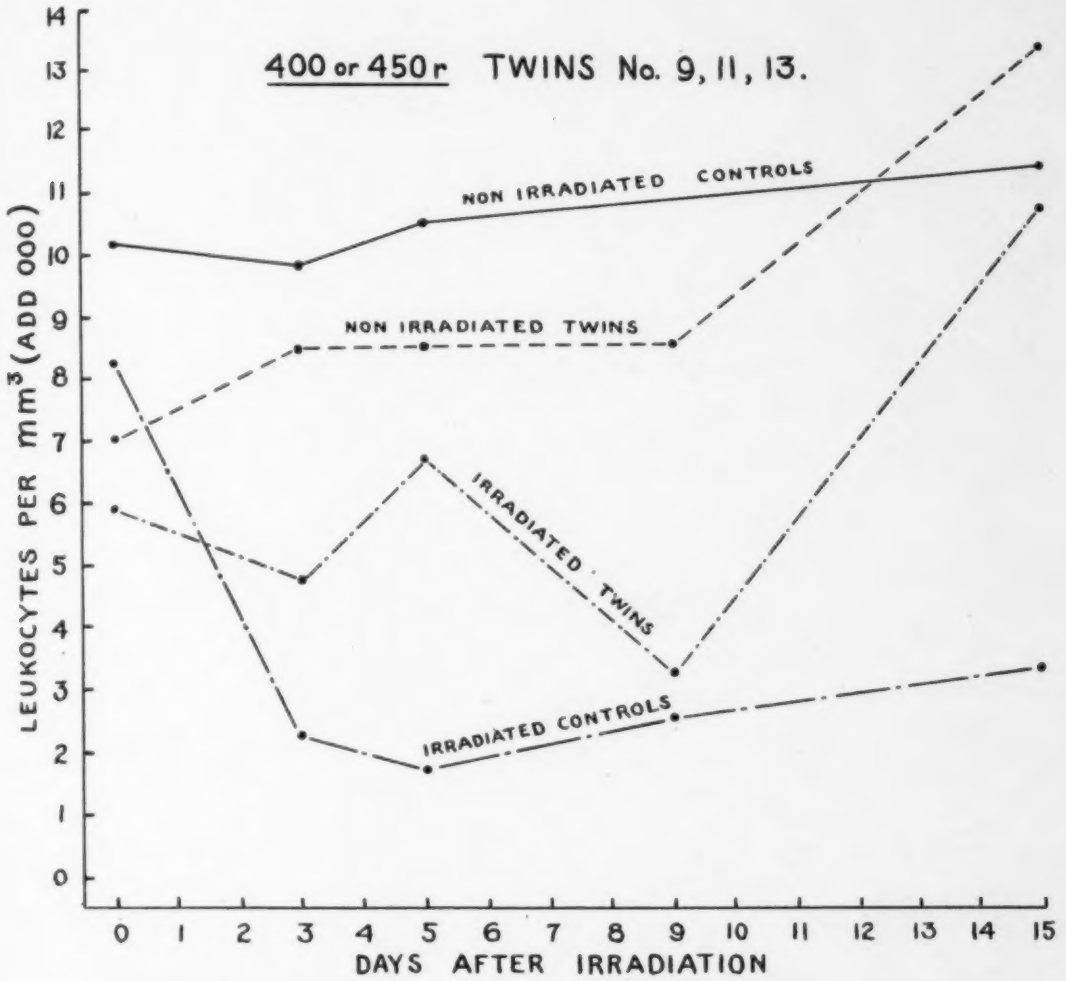


GRAPH 1. Effect of varying doses of roentgen rays on the leukocyte level of the blood of single mice.

1000 r. In this experiment 2 sets of parabiotic twins and 4 single control mice were used. Graph IV shows that irradiation with 1,000 r lowered the number of leukocytes greatly in the irradiated control, slightly less in the irradiated parabiont and considerably less, but definitely, in the non-irradiated parabiont.

Comment. These experiments show that

when one member of a pair of parabiotic mice was irradiated with from 450 to 1,000 r there was leukopenia in the irradiated parabionts, the degree being in direct proportion to the quantity of roentgen rays employed. There was no leukopenia in the non-irradiated parabiont after exposure of its twin to 450 r. When its twin received 800 or 1,000 r there was moderate to marked drop in the leukocyte level of the non-irradiated parabiotic mouse. The reduction of the number of leukocytes in the irradiated parabiont is less marked than in the irradiated single control and the return toward normal occurs sooner.


400 or 450 r TWINS No. 9, 11, 13.
NON IRRADIATED CONTROLS
NON IRRADIATED TWINS
IRRADIATED TWINS
IRRADIATED CONTROLS
LEUKOCYTES PER mm³ (ADD 000)
DAYS AFTER IRRADIATION
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

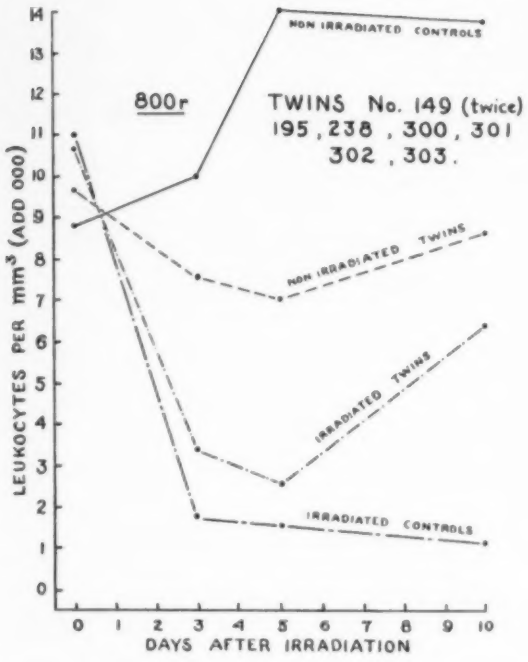
Graph II. Effect on the leukocyte level of parabiotic mice of irradiation of one member with 400 or 450 r.

QUALITATIVE CHANGES IN THE BLOOD PICTURE PRODUCED BY ROENTGEN RAYS IN SINGLE AND PARABIOTIC MICE

It is well known that lymphoid cells are most sensitive to roentgen rays, and that their number in the blood of irradiated animals decreases more rapidly than that of cells of the myeloid series.

Single Mice

In order to compare the qualitative changes in the blood picture of parabiotic mice with those in single mice following irradiation, differential counts of 9 single mice exposed to 400 r were made for a



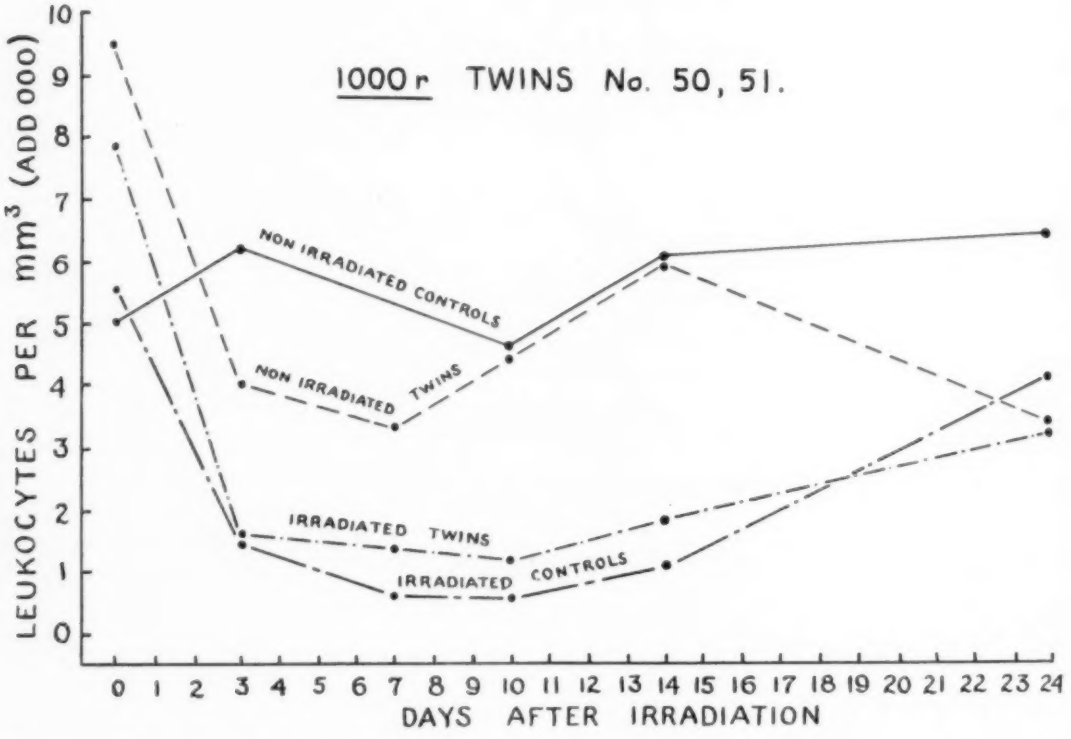
GRAPH III. Effect on the leukocyte level of parabiotic mice of irradiation of one member with 800 r.

period of fifty-four days. In Graph v the average numbers of polymorphonuclear leukocytes and lymphocytes are plotted before and at varying intervals after irradiation together with the total number of leukocytes.

After one day, a conspicuous fall in the number of circulating lymphocytes and a slight rise of polymorphonuclears was noted. Thereafter the polymorphonuclear level fell but returned toward normal more rapidly than that of the lymphocytes. By the twenty-sixth day after irradiation there was a polymorphonuclear leukocytosis which fell to normal by the thirty-second day.

Parabiotic Mice

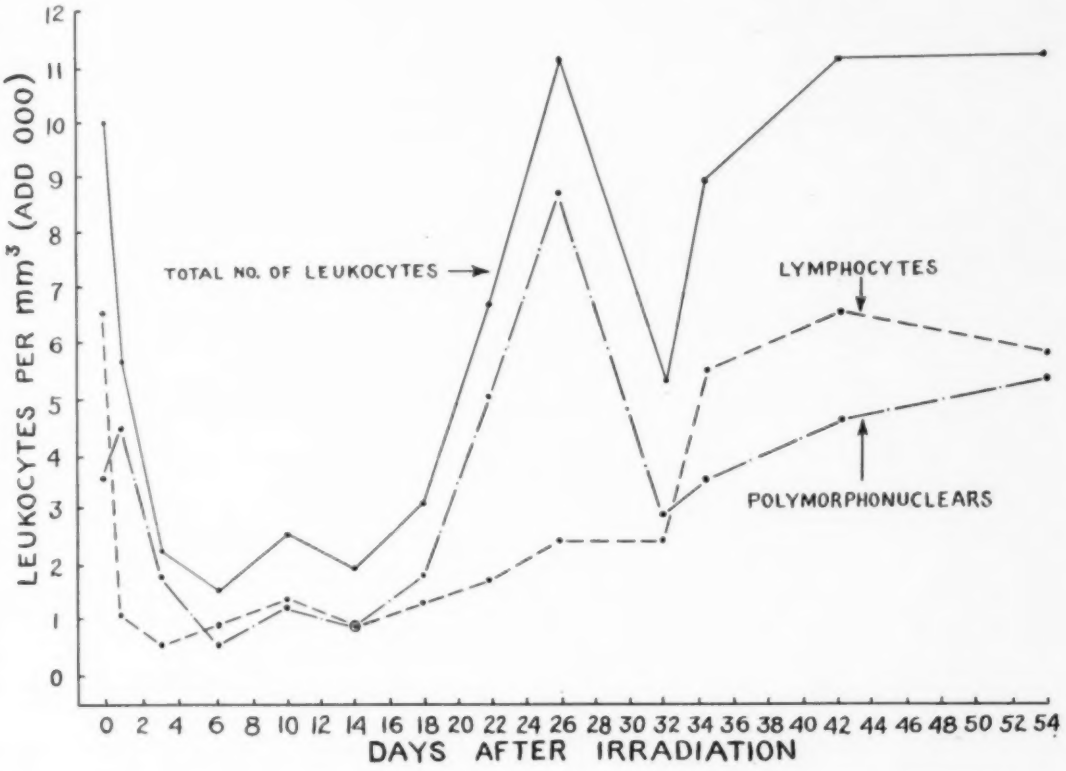
450 r. One member of a parabiotic pair and a single control mouse were irradiated with 450 r. Total and differential leukocyte counts were made of the irradiated mice



GRAPH IV. Effect on the leukocyte level of parabiotic mice of irradiation of one member with 1,000 r.

before and after irradiation as well as of the non-irradiated parabiont and a single non-irradiated control. The results are shown in Graph VI.

Graph VI shows a rapid drop in the number of lymphocytes in the irradiated single control mouse, while the lymphopenia of the irradiated parabiont is less marked. The changes in the differential count are combined and recorded in Graph VII. In the irradiated single mice there was a sudden and profound drop of all leukocytes. In the irradiated parabionts the decrease is similar, but to a lesser degree. The non-irradiated parabionts show a very slight lymphopenia with leukocytosis two weeks

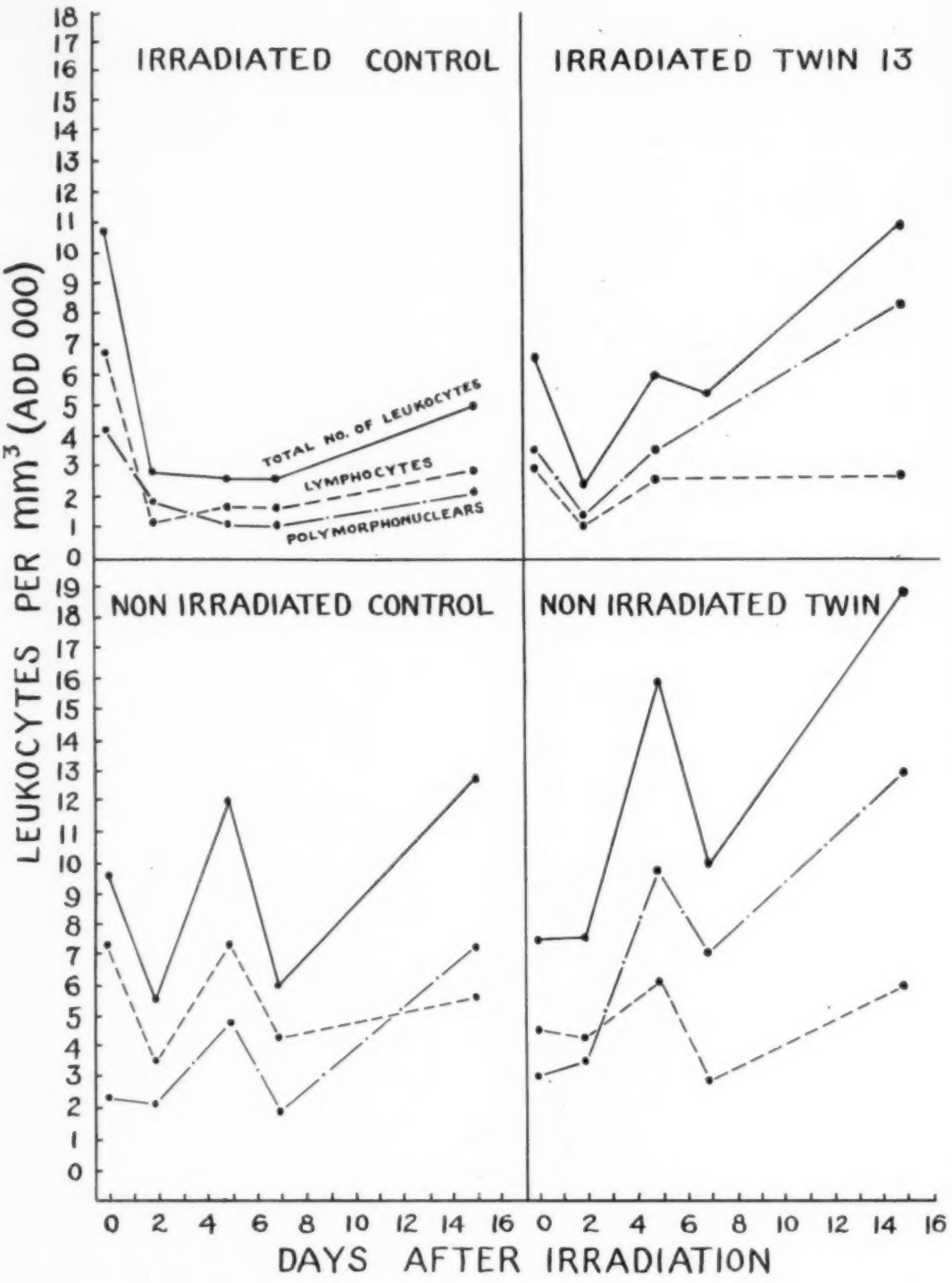


Graph V. Total and differential leukocyte counts on nine single mice irradiated with 400 r.

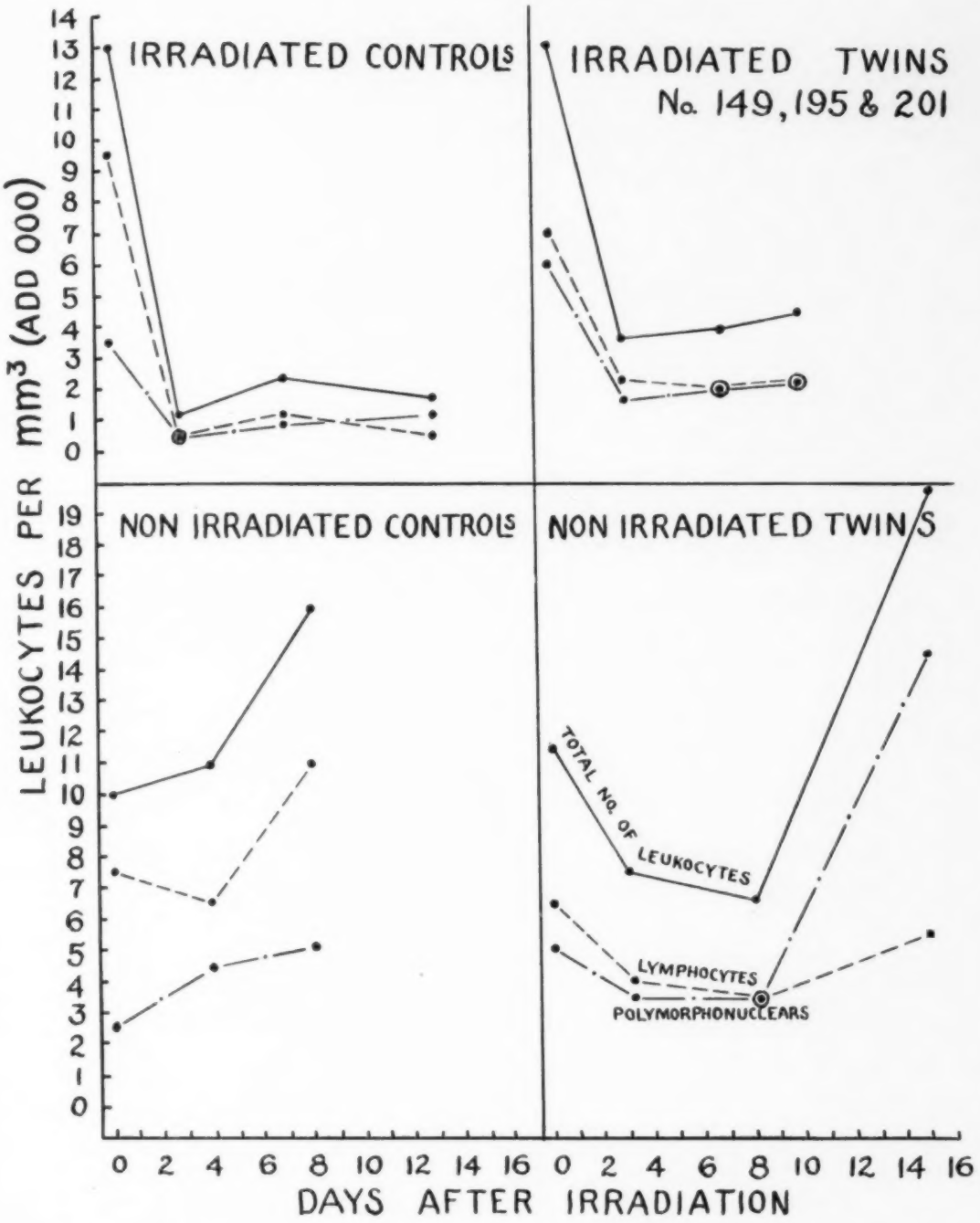
There is a rise of polymorphonuclears and lymphocytes in both the irradiated and non-irradiated parabiont five days after irradiation of the former. The changes in the leukocyte level of the irradiated mouse of this parabiotic pair are obscured because of the preponderance of polymorphonuclear leukocytes before irradiation. However, the effect of irradiation on the lymphocytes in the irradiated twin is less than on those of the irradiated control.

800 r. One member each of 3 parabiotic pairs and 3 control mice were irradiated after irradiation, due to an increase of polymorphonuclear leukocytes.

1,000 r. After irradiation of 1 member of each of 2 parabiotic pairs with 1,000 r the lymphocytes drop very rapidly in the irradiated mouse; similarly, but to a lesser degree, in the non-irradiated parabiont. In the non-irradiated twins there is a more rapid recovery of the lymphocytes than in the irradiated single mice which show profound depression of lymphocytes with no significant recovery after two weeks (Graph VIII).



GRAPH VI. Qualitative changes in the leukocyte level of parabiotic mice following irradiation of one member with 450 r.



GRAPH VII. Qualitative changes in the leukocyte level of parabiotic mice following irradiation of one member with 800 r.

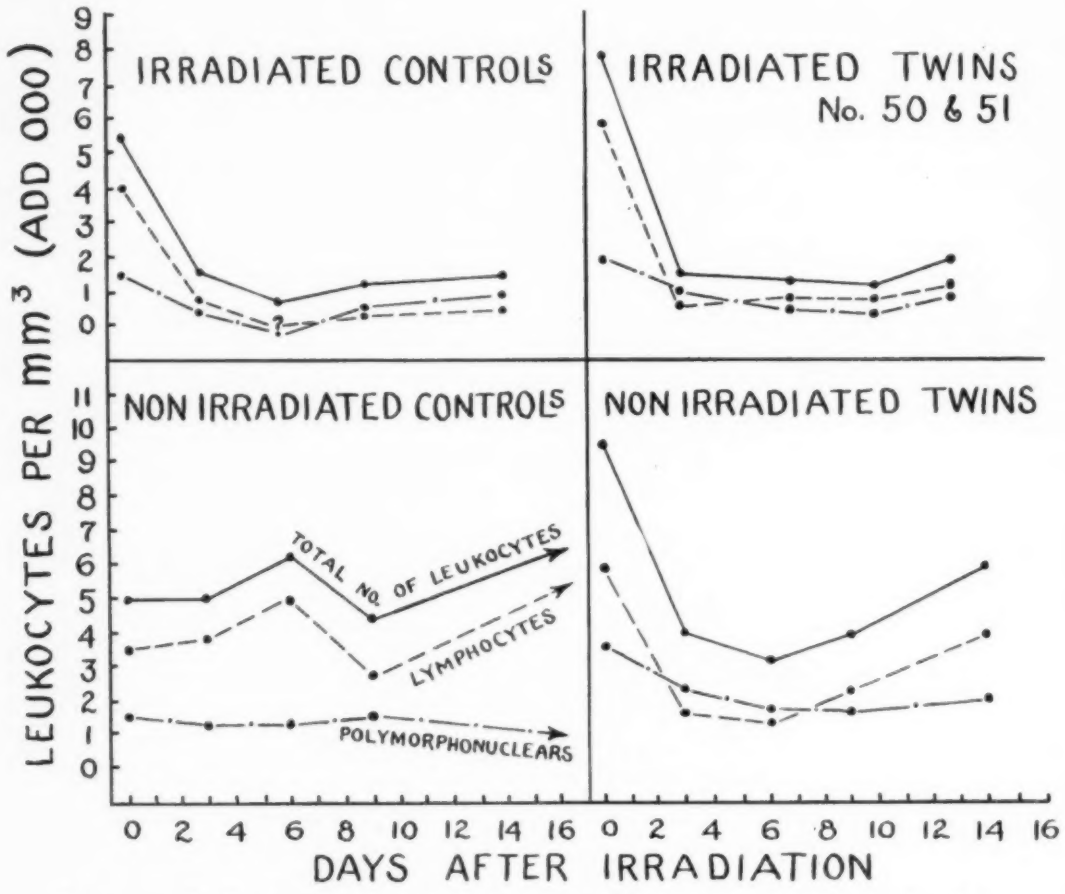
DISCUSSION

Changes similar to those described by others in bone marrow and lymphoid tissues of animals following exposure to roentgen rays have been observed by us. In our experiments, while a large single dose (1,500 r) of roentgen rays produced, after several hours, pyknosis in non-exposed marrow of rabbits, tremendous single doses (6,000 r) directed to a large part of the bodies of mice

failed to produce significant destructive changes in non-exposed marrow from one to several days after irradiation. However, hyperemia, increased numbers of polymorphonuclear leukocytes and later hyperplasia were found. The lymphoid tissues are more susceptible to indirect irradiation.

number in the lymph follicles, while Hsü and Ma[15] irradiated their rats daily during at least eight days and remark "the changes in the lymph node, spleen and unirradiated bone marrow point to hyperactivity of the hematopoietic tissue."

In our experiments with mice, rats and



GRAPH VIII. Qualitative changes in the leukocyte level of parabiotic mice following irradiation of one member with 1,000 r.

Exposure of the abdomen of rats to 3,000 r is followed in several hours by pyknosis of lymphoid cells in the thymus,[cf. 24] and similar changes have been described in non-exposed lymph nodes of irradiated rats and rabbits.[1,15]

In studying the indirect effects of irradiation, Akaiwa and Takeshima[1] exposed their rats to a single dose of roentgen rays and found disintegration of lymphocytes with consequent decrease in their

rabbits, there was conspicuous fragmentation and pyknosis in lymph nodes shielded from the direct action of roentgen rays as early as two hours following exposure to large doses. The following observations suggest that the magnitude of the indirect effect of irradiation is dependent, at least in part, on the volume of tissue exposed, and not alone on the dose of roentgen rays. When 7,280 r was applied to the ear of a rabbit there were no significant changes in

distant non-irradiated lymph nodes. When a smaller dose (2,560 or 3,000 r) was directed to one leg, however, fragmentation and pyknosis of non-irradiated nodes were noted, which were more conspicuous when the entire lower half of the body was irradiated. When the tails only of 6 mice were exposed to 6,400 r there were no significant changes in the lymphoid tissue several hours after irradiation, although smaller doses applied to one-half the body produced conspicuous changes in unexposed lymph nodes.

These observations lend support to the opinion that there is a "factor" produced in an irradiated animal which exerts deleterious effects in parts of the body not directly exposed to the roentgen rays.

In regard to the specificity of changes produced by irradiation, Packard[31] pointed out that cells that are susceptible to roentgen rays are also susceptible to many other agents. In our experiments changes in lymph nodes and bone marrow following actual cautery applied to the skin and following iodoacetic acid poisoning were similar to those observed in unexposed organs of irradiated animals. Such experiments suggest that the changes produced in non-irradiated tissues are due to non-specific factors arising in the irradiated tissues and transported via the blood stream.

The existence of a "toxic" factor in the blood has been described by Macht,[27] who examined by phytopharmacological methods blood from animals and humans before and after irradiation. Blood withdrawn twenty-four hours after irradiation inhibited the growth of seedlings. The "toxic" factor responsible for these phytopharmacological changes, however, has not been demonstrated in the blood within a few hours after irradiation when the changes in non-irradiated tissues are first observed.

The method of parabiosis offers a means to study further the character of the indirect effect of irradiation. If a mouse is joined in parabiosis and irradiated, while its parabiont is completely shielded, alterations in the blood forming organs are similar to those occurring in a single irradiated mouse, but quantitatively there is slightly less damage in the irradiated parabiotic animal. The changes in the non-irradiated parabiont following 800 r to its twin are slight. After a very large dose (6,000 r) to one parabiont, there was hyperemia of spleen and bone marrow, fragmentation of nuclei of lymphoid cells in thymus, lymph node and spleen of its non-irradiated twin seven hours after irradiation. These changes were not present in the non-irradiated parabiont seventy-two hours after irradiation, and were not found four to six days after irradiation with 3,200 r.

Leukopenia occurs in a shielded parabiotic mouse after exposure of its twin to 800 to 1,000 r but the mechanism is not understood. There are at least two possible explanations. Erythrocytes injected into one parabiotic mouse are present in large numbers in the uninjected parabiont after several minutes.[12] Therefore the altered blood of the irradiated parabiont presumably circulates in the vessels of the non-irradiated animal. It may be that following the fall in the number of leukocytes in the irradiated twin, leukocytes migrate from the non-irradiated to the irradiated parabiont. This would result in slight leukopenia in the non-irradiated mouse and would prevent the leukopenia in the irradiated twin from reaching the same low level observed in a single mouse similarly irradiated. Or it is possible that the blood of the irradiated animal is so altered that when it passes to the non-irradiated parabiont it depresses the leukocyte level of the latter, but being diluted in the blood of the non-irradiated parabiont leukopenia is less in the irradiated twin than in a single mouse similarly irradiated. Both mechanisms may operate.

Leukopenia in an irradiated parabiont is less severe than that in an irradiated single animal. With moderate doses of roentgen rays, changes in the blood forming tissues of the non-irradiated parabiont are slight and the leukopenia is transient.

Differential counts show that the decreased leukocyte level in the irradiated twin is due to a fall in both myeloid and lymphoid cells, more especially the latter. The leukopenia in the non-irradiated twin similarly is due largely to a lymphopenia.

This can be explained either by passage of lymphocytes from shielded to irradiated animal or by the transfer of a noxious agent from the irradiated to shielded twin. Evidence for the former has been presented; the degenerative changes in the lymphoid tissues of shielded twins whose twin had received large doses of roentgen rays indicate passage of this toxic agent.

These experiments suggest the possibility that an animal united to another by parabiosis might survive larger doses of roentgen rays. A few experiments have supported this assumption. Single mice almost invariably die following exposure to 1,000 r, but if joined to another mouse by parabiosis they may survive.

SUMMARY AND CONCLUSIONS

Roentgen irradiation produces pathological changes in unexposed lymphoid tissue and bone marrow of rodents. This injury is due to nonspecific factors carried from damaged tissue by way of the circulatory system, and its degree depends, among other factors, on the dose of roentgen rays and probably on the volume of tissue irradiated. The indirect damage is slight as compared to the direct effect.

Parabiosis diminishes the deleterious effects of irradiation. When one member of a parabiotic pair is irradiated, the pathological changes in the blood and blood forming tissues of the irradiated mouse are less conspicuous than those in a single mouse similarly irradiated, while in the non-irradiated parabiont the changes are only slight. These observations indicate that the indirect effect of roentgen rays on lymphoid tissue and bone marrow are due to humoral factors.

REFERENCES

1. AKAIWA, H., and TAKESHIMA, M. Reaction of lymphoid tissue to roentgen radiation. AM. J. ROENTGENOL. & RAD. THERAPY, 1930, *24*, 42–46.
2. VON ALBERTINI, A. Die "Flemming'schen Keimzentren." *Beitr. z. path. Anat. u. z. allg. Path.*, 1932, *89*, 183–228.
3. AUBERTIN, C., and BEAUJARD, E. Action des rayons X sur le sang et les organs hematopoietiques. *Compt. rend. Soc. de biol.*, 1905, *58*, 217–219.
4. BEHNE. Versuch einer Analyse der biologischen Strahlenwirkung. *Deutsche med. Wchnschr.*, 1920, *46*, 223–224.
5. BRINNITZER, H. N. Blutkrankheiten als Strahlenfolge. *Strahlentherapie*, 1935, *52*, 699–716.
6. BUNSTER, E., and MEYER, R. K. An improved method of parabiosis. *Anat. Rec.*, 1933, *57*, 339–343.
7. CASPARI, W. Biologische Grundlagen der Strahlenbehandlung bösartiger Geschwülste. In: Handbuch d. ges. Strahlenheilkunde. P. Lazarus, Editor. Vol. 1. J. F. Bergmann, München, 1928.
8. COLWELL, H. A. The Method of Action of Radium and X-Rays on Living Tissues. Oxford University Press, London, 1935.
9. COLWELL, H. A., and RUSS, S. Radium, X Rays and the Living Cell. Second edition. G. Bell & Sons, London, 1924.
10. DESJARDINS, A. U. Radiotherapy for inflammatory conditions. *J. Am. M. Ass.*, 1931, *96*, 401–408.
11. FAILLA, G. A theory of the biological action of ionizing radiations. *Cancer Probl., Symposium*, 1937, pp. 202–214.
12. FURTH, O. B., BARNES, W. A., and BROWER, A. B. Studies on resistance to transmissible leukemia in mice by means of parabiosis. *Arch. Path.*, 1940, *29*, 163–174.
13. HEINEKE, H. Ueber die Einwirkung der Röntgenstrahlen auf die Tiere. *München. med. Wchnschr.*, 1903, *2*, 2090–2092. Zur Kenntnis der Wirkung der Radiumstrahlen auf tierische Gewebe. *München. med. Wchnschr.*, 1904, *2*, 1382–1384. Experimentelle Untersuchungen über die Einwirkung der Röntgenstrahlen auf innere Organe. *Mitt. a. d. Grenzgeb. d. Med. u. Chir.*, 1905, *14*, 21–94.
14. HELBER, E., and LINSER, P. Experimentelle Untersuchungen über die Einwirkung der Röntgenstrahlen auf das Blut. *München. med. Wchnschr.*, 1905, *1*, 689–691.
15. HSÜ, C. L., and MA, W. C. Direct and indirect effects of roentgen radiation on the blood-forming organs of rats. *Am. J. Cancer*, 1940, *39*, 319–333.

16. Hussey, R. G. Influence of x-rays on properties of blood. *J. Gen. Physiol.*, 1922, *4*, 511–516.
17. Jolly, J., and Lacassagne, A. De la résistance de leucocytes du sang vis-à-vis de rayons X. *Compt. rend. Soc. de biol.*, 1923, *89*, 379–382.
18. Jolly, J. Mode d'action des rayons X sur les cellules. *Compt. rend. Soc. de biol.*, 1924, *91*, 79–80. Action de rayons X sur les cellules. *Compt. rend. Soc. de biol.*, 1924, *91*, 532–534.
19. Kluge, L., and Zwerg, H. G. Ueber die Wirkung der Röntgenbestrahlung auf den Mineralstoffwechsel von multiplen Impfsarkomen der weissen Ratte. *Strahlentherapie*, 1933, *46*, 293–310.
20. Knott, F. A., and Watt, W. L. Some effects of deep x-rays upon the cells of the blood. *Brit. M. J.*, 1929, *1*, 542–543.
21. Krause, P., and Ziegler, K. Experimentelle Untersuchungen über die Einwirkung der Röntgenstrahlen auf tierisches Gewebe. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1906–1907, *10*, 126–182.
22. Krömeke, F. Ueber die Einwirkung der Röntgenstrahlen auf die roten Blutkörperchen. *Strahlentherapie*, 1926, *22*, 608–652.
23. Langer, H. Roentgen rays and the autonomic nervous system. Am. J. Roentgenol. & Rad. Therapy, 1927, *18*, 137–145.
24. Leblond, C. P., and Segal, G. Action des toxiques sur le thymus de l'animal sans surrénale. *Compt. rend. Soc. de biol.*, 1938, *129*, 838–840.
25. Lewis, W. H., and Lewis, M. R. General Cytology. University of Chicago Press, Chicago, 1924.
26. Liechti, A. Ueber Reaktionsänderungen im Röntgenbestrahlten Gewebe. *Klin. Wchnschr.*, 1926, *5*, 1911–1913.
27. Macht, D. I. Pharmacology of human blood after its exposure to roentgen rays. Am. J. Roentgenol. & Rad. Therapy, 1941, *45*, 446–449.
28. Minot, G. R., and Spurling, R. G. Effect on the blood of irradiation, especially short wave length roentgen-ray therapy. *Am. J. M. Sc.*, 1924, *168*, 215–241.
29. Mottram, J. C. Action of radium on blood supply: white reaction. *Brit. J. Radiol.*, 1932, *5*, 643–645.
30. Pack, G. T. Pathology of burns. *Arch. Path. & Lab. Med.*, 1926, *1*, 767–805.
31. Packard, C. Biological effects of short radiations. *Quart. Rev. Biol.*, 1931, *6*, 253–280.
32. v. Pannewitz, G. Beeinflussung des Säure-Basenhaushaltes durch Röntgenstrahlen. *Strahlentherapie*, 1926, *24*, 327–330.
33. Raspe, R. Biologische Wirkung der Strahlen mit besonderer Berücksichtigung der Tuberkuloseforschung. *Zentralbl. f. d. ges. Tuberk.-Forsch.*, 1939, *49*, 513–531.
34. Regaud, C. L., and Lacassagne, A. Die Histophysiologische und pathologisch-anatomischen Grundlagen der Strahlenbiologie und -Therapie. In. Handbuch d. ges. Strahlenheilkunde. P. Lazarus, Editor. Vol. 1. J. F. Bergmann, München, 1928, pp. 258–304.
35. Rother, J. Ueber den Angriffspunkt der Röntgenstrahlenwirkung am biologischen Objekt. *Strahlentherapie*, 1928, *27*, 197–256.
36. Scott, C. M. Some Quantitative Aspects of Biological Action of X and γ Rays. Med. Research Council, Special Report Series, No. 223. His Majesty's Stat. Off., London, 1937.
37. Shouse, S. S., Warren, S. L., and Whipple, G. H. Aplasia of marrow and fatal intoxication in dogs produced by roentgen radiation of all bones. *J. Exper. Med.*, 1931, *53*, 421–435.
38. Siciliano, L., and Buonamici, C. B. Studi sul midollo osseo sotto l'azione dei raggi X. *Arch. di radiol.*, 1930, *6*, 1108–1136.
39. Sipowsky, P. W. Directe und "reflektorische" Wirkung auf das Knockenmark. *Vestn. rentgenol.*, 1934, *13*, 263–269. Quoted from *Zentralbl. f. d. ges. Radiol.*, 1935, *19*, 551–552.
40. Stedman, D. F., and Laurence, G. C. A poison theory of the effects of irradiation. Third International Cancer Congress, 1939.
41. Taylor, H. D., Witherbee, W. D., and Murphy, J. B. Studies on x-ray effects. *J. Exper. Med.*, 1919, *29*, 53–73.
42. Tsuzuki, M. Experimental studies on biological action of hard roentgen rays. Am. J. Roentgenol. & Rad. Therapy, 1926, *16*, 134–150.
43. Weiskotten, H. G. Histopathology of superficial burns. *J. Am. M. Ass.*, 1919, *72*, 259–261.
44. Woenckhaus, E. Beitrag zur Allgemeinwirkung der Röntgenstrahlen. *Arch. f. exper. Path. u. Pharmakol.*, 1930, *150*, 182–197.
45. Wünsche, H. W. Fortlaufende Untersuchungen über den Einfluss der Röntgenstrahlen auf das Knochenmark. *Arch. f. exper. Path. u. Pharmakol.*, 1938, *189*, 581–599.
46. Zacherl, H. Beitrag zur Allgemeinwirkung der Röntgenstrahlen. *Strahlentherapie*, 1926, *23*, 272–287.
47. Zwerg, H. G. Ueber die Allgemeinwirkung der Röntgenstrahlen mit besonderer Berücksichtigung ihres zeitlichen Auftretens. *Strahlentherapie*, 1932, *45*, 297–306.

AN INVESTIGATION INTO SOME PRACTICAL ASPECTS OF ROENTGEN-RAY STEREOPTICS*

PART I. A FALLACY IN THE CURRENT PRACTICE OF STEREOROENTGENOGRAPHY

PART II. SINGLE-FILM STEREOROENTGENOGRAMS—A NEW AND SIMPLE METHOD OF STEREOROENTGENOGRAPHY

PART III. A DEVICE FOR MEASURING DEPTH IN SINGLE-FILM STEREOROENTGENOGRAMS

By EDWARD KLEIN, D.D.S., MILTON KLEIN, D.D.S., HAROLD KLEIN, D.D.S.,† *and* ALLEN T. NEWMAN, M.D.‡

NEW YORK, NEW YORK

PART I

A FALLACY IN THE CURRENT PRACTICE OF STEREOROENTGENOGRAPHY

THE principle of stereoptics is well known. Objects viewed with a normal pair of eyes appear to have depth and distance because of man's natural stereoscopic vision. Each eye receives a slightly different view and the two images are fused by the brain to give the stereoscopic impression. Similarly if two photographs of the same object are made from slightly different positions and then viewed in some type of stereoscope so that each eye sees only one image, the brain can fuse the two images into one so that a true perspective in the correct spatial relation will be seen and an impression of depth received.

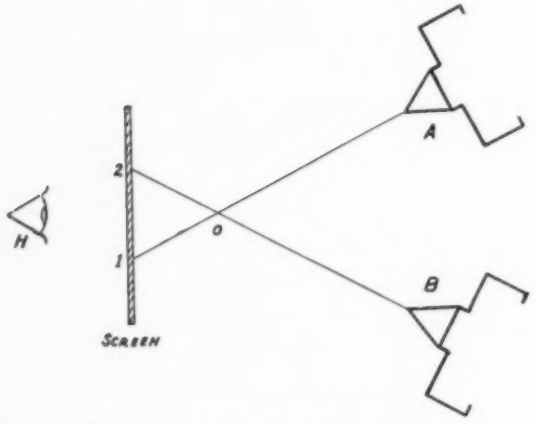


FIG. 1. *A*, roentgen tube in first position; *B*, roentgen tube in second position; *O*, object; *1*, shadow of object (*O*) on screen from roentgen tube (*A*); *2*, shadow of object (*O*) on screen from roentgen tube (*B*); *H*, eye.

Following the discovery of the roentgen rays, Sir J. MacKenzie Davidson applied this photographic stereoptical principle to roentgenography. Davidson's application is still used and has not been essentially changed up to the present time. The following quotation from the "Manual" by Sante[1] presents the modern concept:

Stereoscopic roentgenography is based on the same principle as stereoscopic vision. The two eyes see an object from two different viewpoints, approximately 2.5 inches apart—the average distance between the pupils of the two eyes. The two images thus secured are correlated in the brain giving the sense of depth.

In stereoscopic roentgenography, the same principle is carried out; two separate exposures are made, with different positions of the focal point of the tube 2.5 inches apart, without disturbing the position of the patient. If the eyes are placed in the two positions of the focal spot they would obtain similar impressions to those recorded by the two X-ray exposures on the X-ray films. If by means of a stereoscope, these two roentgenograms are viewed simultaneously, the right eye viewing the roentgenogram taken by the right shift of the target, the

[1] Sante, L. R. Manual of Roentgenological Technique. Edwards Brothers, Inc., Ann Arbor, Mich., 1940.

* Presented at New York University College of Dentistry, August 7, 1942, and at Walter Reed Hospital, Washington, D. C., October 20, 1942.

† Research Associates in Radiology— New York University.

‡ Dean, New York University College of Dentistry; Director of Research Clinics.

left eye viewing the roentgenogram taken by the left shift of the target, then the two images will be correlated in the brain giving a sense of depth to the subject.

The results obtained by this technique have not been satisfactory because it has not been recognized that, while the basic principle of stereoptics remains unchanged and unchangeable, its application in roentgenography is different from that in photography. A photograph is the image of an object; a roentgenogram is the image of the *shadow* of an object cast upon a screen at some distance from the object. A roentgenogram is, therefore, the picture of a shadow.

The New Concept. The new concept depends upon recognition of this fact that what the eye sees in a roentgenogram is not the object itself but the *shadow* of the object. Figure 1 makes this clear. The first position of the roentgen tube (*A*) casts a shadow of the object (*O*) at (*1*). The second position of the roentgen tube (*B*) casts a shadow of the object (*O*) at (*2*). Because the eye (*H*) views the *shadow* of the object and not the object itself, it is the amount of *displacement of the shadows*, that is to say, the distance between (*1*) and (*2*) which is the controlling factor and not the distance which the roentgen tube moves.

Since the eyes do not view the object from the same position as does the roentgen tube, the tube should not be moved as if it were a camera. We have established by trial and error that if the shadow displacement is greater than $\frac{3}{8}$ inch the average individual viewing these two roentgenograms through a stereoscope at reading distance will not be able to fuse the two images to obtain a sense of depth. Only young individuals or persons of considerable experience with stereoptical pictures can fuse displacements of greater degree. Recognition of this fact is what has made successful stereoroentgenograms possible.

How to Calculate the Correct Displacement of the Tube. The shadow of the part of the object nearest the roentgen tube and farthest away from the film is displaced the greatest distance when the roentgen tube is moved. Thus in Figure 2 the shadow of (*C*) has a greater displacement than the shadow of (*D*). Moreover, the farther the object is away from the film, the greater will be its displacement. But as explained, the shadows thrown by (*C*) must not be greater than $\frac{3}{8}$ inch apart. If, then, it is arranged that no matter what distance (*C*) is away from the film, the displacement shall be *not more* than $\frac{3}{8}$ inch, then the shadows of all other points will have less

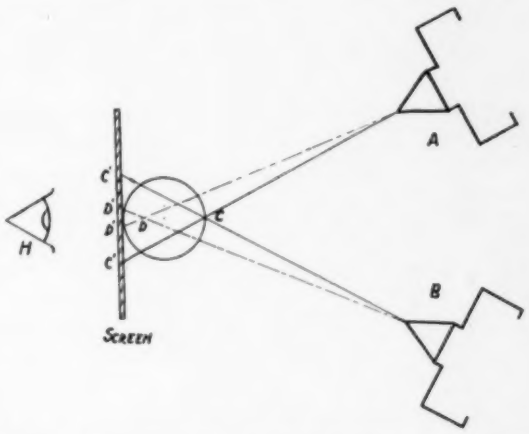


Fig. 2. *A*, roentgen tube in first position; *B*, roentgen tube in second position; *C*, point of object farthest away from screen; *C'*, shadow of object (*C*) from roentgen tubes (*A*) and (*B*); *D*, point of object nearer than (*C*) to the screen; *D'*, shadow of object (*D*) from roentgen tubes (*A*) and (*B*); *H*, eye.

displacement than $\frac{3}{8}$ inch and thus be readily fusible. In other words, the maximum amount of displacement being fixed, the amount of movement of the tube has to vary for each object to be roentgenographed. This distance can be calculated very simply.

Example 1

In Figure 3, $\frac{3}{8}$ inch displacement of the shadow of (*C*) is required.

Most distant point of object from film..10 in.
Anode to point of object.....20 in.
Film-anode distance.....30 in.
Then $\frac{3}{8}:10::X:20$. Therefore $X=\frac{3}{4}$ in.

Example 2

Take another instance in which the distance of the object (*C*) from the film is 6 inches and from the anode 30 inches. Then $\frac{3}{8}:6::X:30$. Therefore $X=1\frac{7}{8}$ in.

Thus in Example 1, $\frac{3}{8}$ inch displacement will be obtained if the roentgen tube is moved between each exposure a distance of $\frac{3}{4}$ inch in a horizontal straight line. In Example 2, however, the tube will need to be moved $1\frac{7}{8}$ inch to obtain the same displacement.

When this formula is strictly adhered to, the two resultant roentgenograms are fusible for the average individual and can justly be called true stereoroentgenograms.

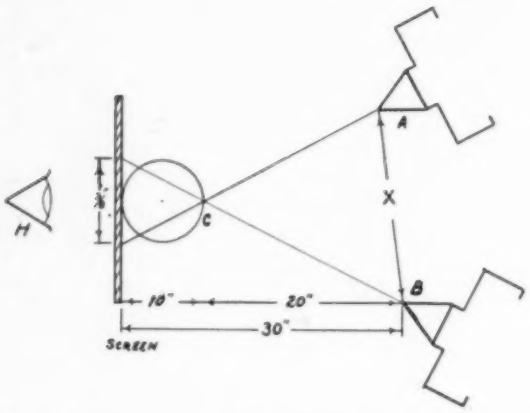


FIG. 3. *A*, roentgen tube in first position; *B*, roentgen tube in second position; *C*, point of object farthest away from screen; *H*, eye; *X*, distance of roentgen tube shift from (*A*) to (*B*).

The procedure for taking these stereoroentgenograms is the usual one. When taking the first roentgenogram the operator directs the tube at the object in the usual way. He then moves the tube to his left the calculated distance. In order to facilitate this, the rod carrying the tube should be calibrated in eighths of an inch. Since at present this is not done, the calculated distance must for the time being be measured with a ruler. The second exposure is then made.

The films so obtained may be viewed by any method such as the converging lens stereoscope or the reflecting mirror (Wheatstone) stereoscope at reading distance.

Summary. It has been shown that the current practice of producing stereoroentgenograms based on the photographic principle of the interpupillary distance is incorrect.

Because the roentgenogram is not an image of the object but a *shadow* of that object, allowance has to be made for the distance of the object from the film.

It has been found that the maximum deviation between the shadows on the two roentgenograms which can be readily fusible by the average individual is $\frac{3}{8}$ inch.

For this reason, the displacement of the tube must be varied in each case to insure that no more than this maximum deviation be produced.

The formula for calculating the displacement of the tube is given.

PART II

SINGLE-FILM STEREOROENTGENOGRAMS—A NEW AND SIMPLE METHOD OF STEREOROENTGENOGRAPHY

In Part I we have demonstrated a fallacy in the current practice of making stereoroentgenograms, and a new technique of taking stereoroentgenograms which makes them readily readable by even the inexperienced eye. In this part we are concerned with a method of using this technique to produce on a single film a roentgenogram which, when viewed through polarizing spectacles, gives the same effect of depth as when two roentgenograms taken from different angles are viewed in a stereoscope. Cumbersome and costly stereoscopic apparatus thus becomes unnecessary.

The Single-Film Stereoroentgenogram. A single tri-dimensional film has been adopted for this purpose. The principle of this special film is that each side of it polarizes the light at right angles to the other. The image on each side corresponds respectively to the images of the two stereoscopic roentgenograms. These are viewed through special spectacles, each lens of which is polarized at right angles to the other. The degree of angulation of one side of the print corresponds to the degree of angulation of one lens and that of the other side of the print to the degree of angulation of the other lens. Thus each eye picks up the image of only one side of the negative. These two separate images are fused in the

brain, producing the stereoptic picture.

The single-film stereoroentgenogram has several advantages over the usual double-film type. It can, for instance, be projected on a screen and thus a stereoscopic view be obtained by a whole audience instead of by one person only at a time.

To do this, the stereoroentgenogram is placed in an ordinary lantern slide projector and projected on a metallic screen, made by painting a glossy surface with aluminum paint. The function of the aluminum screen is to maintain the polarization of light. Alternatively the film may be aluminum-painted on one side and viewed as a reflection type print. Finally, both film and reflection type print can be viewed through a magnifying glass without depolarizing the light and therefore a stereoptic view is still obtained.

How to Produce the Single-Film Stereoroentgenogram. The usual two roentgenograms are taken. When the first has been taken, the tube is moved to the *left* over the distance calculated, as described in Part 1, and the second roentgenogram is taken. This second roentgenogram is known as the *left hand* roentgenogram, and it is important so to mark it for use in the process of developing.

The process described below is now followed.

1. Develop the two exposed films in the normal manner. Lay them down in ordinary viewing position, and turn the second, or *left hand* roentgenogram over. This gives a mirror image to the first roentgenogram. Turn off the light and illuminate the darkroom with a Wratten Safelight, series "O" or "OA." Place a Wash-Off Relief Film (as used in color photography), shiny side up on a flat surface. Place one of the developed roentgenograms over the Wash-Off Relief Film, and then expose it to a light source from above. When using a 10 watt bulb, 3 ft. distance, the exposure time varies from four to twelve seconds. If the film is very thin and the light source too great, the bulb may be obscured to diminish the candle power.

Fig. 4. Two blurred images appear to the naked eye.

2. Now attach a clip to the Wash-Off Relief Film and immerse the film in the developing solution, holding the smooth side to the bottom of the tray. This is done so that the gelatin is not scratched by the bottom of the tray, the gelatin being on the rough side. Agitate gently in the developing solution from one to two minutes. The above steps give an opportunity to exercise further control and to remedy faults of over or under exposure of the original roentgenograms. The developing time is proportionate to the density of the film.

3. The film is next washed in water and quickly immersed in the Wash-Off Relief bath. Agitate vigorously for one minute with the gelatin side facing up so that the tray does not scratch it. This washes off all the undeveloped gelatin and the ordinary lights can then be turned on.

4. Rinse the film in running water to complete the process of washing off the undeveloped gelatin, which may be assisted by gently rubbing with the fingers.

5. Hang this film out of the way and

process the second developed roentgenogram, using the same times for exposures, developing and wash-off bath.

Note: If both films are exposed and processed in the same operation the resulting Wash-Off Relief Films will be of exactly the same quality and there will be a saving of time.

6. Register both Wash-Off Relief Films by putting their gelatin sides face to face so that their edges agree and clip them securely together. The images then overlap each other to the maximum of $\frac{3}{8}$ inch.

7. Now attach a strip of adhesive along the length of the top border of the upper film, with half of its breadth free. Turn the films over and apply another piece of tape similarly so that the free edges of the tape stick to each other. To reinforce this hinge, place an additional strip of adhesive on top of the other two strips on each side, slightly overlapping and sticking to each other. Punch two or three holes, depending on the size of the film, through the hinge where the film ends, so that half the hole is through the films. These are used for drainage of the printing solution which occurs in a later step.

8. Immerse the resulting registered films for one minute in a bleaching solution which takes out the silver stain and hardens the gelatin. Rinse in running water until all the color of the film is washed out. Immerse the films for two minutes in the printing solution, keeping the surfaces of the films apart by a metal rod. The gelatin of the film absorbs the printing solution in proportion to the thickness of the gelatin relief.

9. Remove the films from the solution and spread them apart without detaching them at the hinge. The excess ink drains out through the holes in the hinge.

10. Insert a commercially prepared sheet of special polarizable material between them and pass the three, hinge-first, through a wringer with rubber rollers which apply a moderate pressure. This transfers to each side of the polarizable sheet the respective relief images contained on each Wash-Off Relief Film. The amount of ink transferred determines the degree of polarization, and so produces a roentgenogram of varying densities.

11. Leave the polarizable sheet between the two Wash-Off Relief Films for one minute, then peel them off. At once mark the part of the sheet which was nearest the hinge, "Top." (If the top of the sheet is held at the bottom, the shadows on the roentgenogram will appear to recede instead of advance; and if the right hand picture, instead of the left, is turned, to make the mirror image, the shadows will also recede.)

12. The print is now ready, and appears as two blurred images, as in Figure 4. It may be viewed immediately, through the special spectacles, and will appear in stereoptic relief.

For a permanent record, allow the print to dry for five minutes and lacquer both sides of the polarized sheets to avoid scratching.

This process, though it takes time in the describing, is in fact simple and quick. It does not require more skill than can be reasonably expected from a roentgen-ray technician, and the whole process, from the completed roentgenograms to the wet stereoroentgenogram ready for examination can be completed in seven minutes.

Summary. A method has been described whereby a stereoroentgenogram can be produced on a single film. This single-film stereoroentgenogram, when viewed through polarized spectacles, gives a tri-dimensional view. Moreover, it can be viewed by more than one person at a time, or be projected on a screen and demonstrated to an audience. Reflection type and transparent prints can be studied through a magnifying glass.

It will be apparent, therefore, that the single-film stereoroentgenogram represents a great advance over the two-film stereoroentgenogram which can be viewed only in a special apparatus and by one person at a time. Production of the single-film stereoroentgenogram does not require

highly trained technicians nor expensive equipment. Its use is thus not limited to large hospitals. The single-film stereoroentgenogram should have great use at the present time in war surgery. It should accelerate operative procedures by the military surgeon in the field since it can be applied wherever a roentgen-ray unit is carried, it can be taken into forward areas, and it is unaffected by climatic conditions.

Acknowledgment. We wish to express here our appreciation to Dr. Allen T. Newman Dean, New York University, College of Dentistry, for his help in providing facilities, and to Polaroid Corporation of Cambridge, Massachusetts, for supplying materials used in this investigation, and to Surgeon Lieut. Commander John F. M. Milner, Royal Navy, Dr. Miles Atkinson and Mr. John H. Shaw for their helpful cooperation.

PART III

A DEVICE FOR MEASURING DEPTH IN SINGLE-FILM STEREOROENTGENOGRAMS

In the previous part we have shown some of the advantages possessed by the single-film stereoroentgenogram over the conventional double-film stereoroentgenograms in current use. These advantages lie in its simplicity of viewing and making, its cheapness and its universal applicability. But the single-film stereoroentgenogram possesses yet another and even greater advantage than any of these, which is that the depth it portrays can actually be measured, and with great accuracy. By means of a simple device it is possible to calculate the precise depth at which, for instance, a foreign body embedded in the tissues lies from the surface. When the unsatisfactory nature of the present methods of measuring spatial relationships in stereoroentgenograms is borne in mind, it is apparent that this possibility represents a considerable advance.

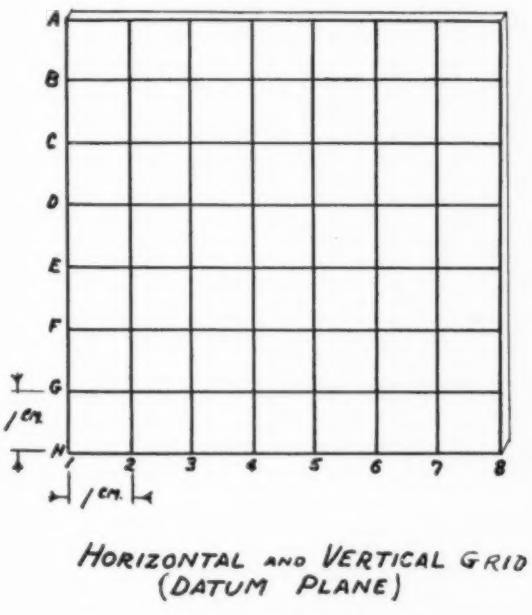


Fig. 5. Horizontal and vertical grid.

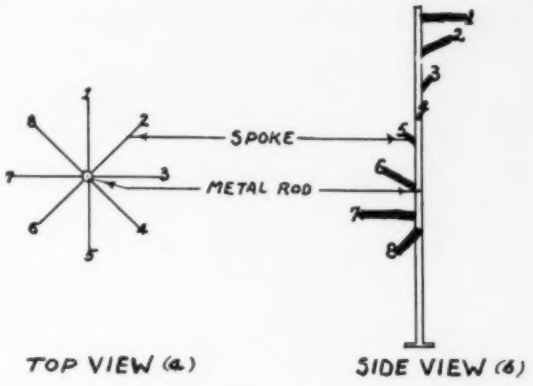


Fig. 6. Vertical depth grid.

The Depth Measuring Grid. The grid which we have devised consists of two parts, a horizontal-vertical and a depth grid.

1. The horizontal-vertical grid is made of a 14 by 17 inch sheet of plastic material transparent to roentgen rays. Embedded in this plastic material are wires, running in a horizontal and vertical direction at distances of 1 cm. apart. The abscissae are designated by letters, the ordinates by numbers, so that any of the squares formed by the crossing wires can be designated (Fig. 5).

2. The depth grid is a long metal rod to which short spokes are attached at right angles and arranged spirally around it (Fig. 6, *a* and *b*). These spokes are spaced at equal distances apart and numbered. Different length grids with different spoke

intervals are necessary according to the size of the object being roentgenographed—hand, chest, etc.—as will be explained later.

The horizontal-vertical grid is incorporated in the cassette and the object to be roentgenographed is placed upon it. The depth grid is attached to the horizontal-

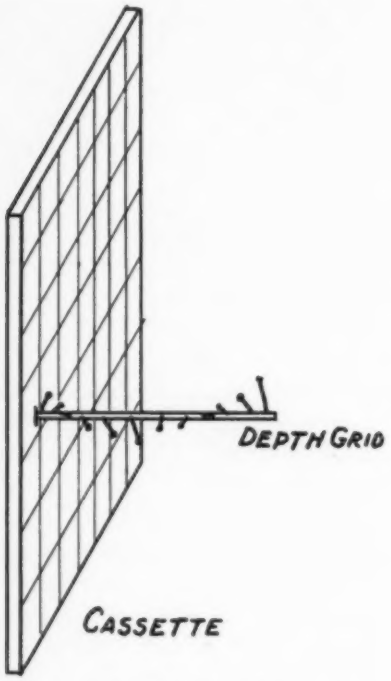


FIG. 7. Depth grid and cassette.

vertical grid at right angles and in contact with the object, thus occupying the third dimension. The resulting roentgenogram shows the images of the object, of the horizontal-vertical grid behind it, and of the depth grid beside it (Fig. 7).

When such a stereoroentgenogram is viewed through the polarizing spectacles, the image of the depth grid will be seen to emerge from the datum plane of the horizontal-vertical grid together with the image of the object. This enables the observer to compare the object-image with the calibrated depth-image since both are in the same stereoptical field (Fig. 8).

Different Sizes and Types of Depth Grid. Different sizes of depth grid must be used according to the part of the body to be roentgenographed—the thicker the part, the coarser the grid. Thus for the hand, a 3 inch long grid with short spokes at small intervals will be suitable, while for the chest, a longer grid with wider spoke spacing will be required. If the foreign body is located between two spokes and more accurate localization is necessary, a finer depth grid can be inserted between these two spokes and another stereoroentgenogram is taken.

We have experimented with several types of depth grid, such as staircase, ladder, concentric circles and continuous spirals. These grids have been applied to special types of work. The depth grid described is the simplest and has been found to be the most generally useful.

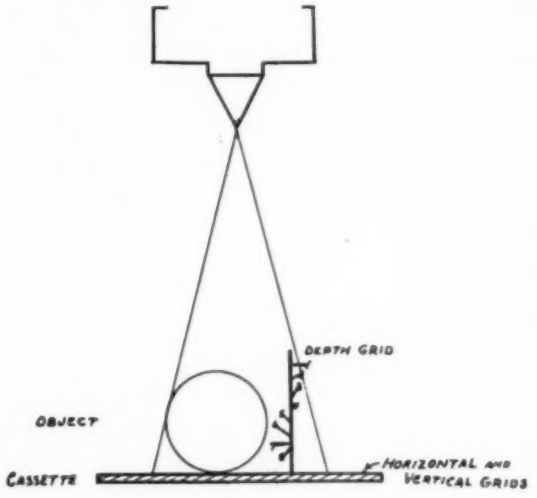


FIG. 8. The horizontal-vertical grid and the depth grid attached to the cassette, object placed in position and roentgenogram taken.

Method of Determining the Position of a Foerign Body.

A. *Lateral Depth.* Obviously this determination is very simple. It is necessary merely to note the square or squares on the horizontal-vertical grid which the foreign body overlies.

B. *Vertical Depth.* There are three methods of calculating vertical depth.

1. By simple observation through the polarizing spectacles, the relationship of the foreign body to one of the numbered spokes can be determined. The distance of that spoke from the horizontal-vertical grid being known, the depth of the foreign body is also known. For instance, if the foreign body is opposite spoke number four, and the spokes are at 1 inch distances on the particular grid in use, the depth of the foreign body from the surface is 4 inches.

2. In order to facilitate this observation, the image of the depth grid in the stereoroentgenogram may be cut off and slid across "into" the object on the stereoroentgenogram, in order to bring the grid closer to the object for easier comparison.

3. This method is mathematically accurate and should be used to check the previous observation, until experience has been gained, particularly for the location of small bodies. Since the stereoptic vision of two observers may differ significantly, the use of this third method employs a polarized ruler. The polarized ruler consists of two transparent polarized sheets 2 by 1 inch, mounted on a 2 inch square of glass. They are secured by scotch tape, one above the other to the glass slab and have their respective fields of polarization at right angles to each other. The junction line, between the two polarized sheets (*A*) and (*B*) as shown in Figure 9, is calibrated in 1/64 of an inch.

Each object appears on the film as two images to the naked eye as in Figure 4. The distance between two shadows of each object is known as the disparity, and this disparity varies with the distance of the object from the eye of the observer. To determine, with mathematical accuracy, the depth of any given object, this disparity must be measured and compared with the disparity of the shadows of the spokes on the grid. The spoke which compares in disparity to the disparity of the object indicates the depth of the object. To determine the grid spoke whose disparity corresponds to that of the foreign body, the polarized ruler is used. First it is slid over the image of the foreign body in the stereoroentgenogram, keeping its calibrated edge parallel to the top of the film. It will then be seen that sheet (*A*) picks up an edge of the foreign body, sheet (*B*) the other edge. The distance between the two is measured with the ruler. Now the ruler is moved over to the grid and slid over the spokes until such a spoke is found, the disparity of which is equal to that measured on the foreign body. That spoke is at the same level as the foreign body.

For greater accuracy of localization, the skin surface should not be used as the base line for measurement, particularly in re-

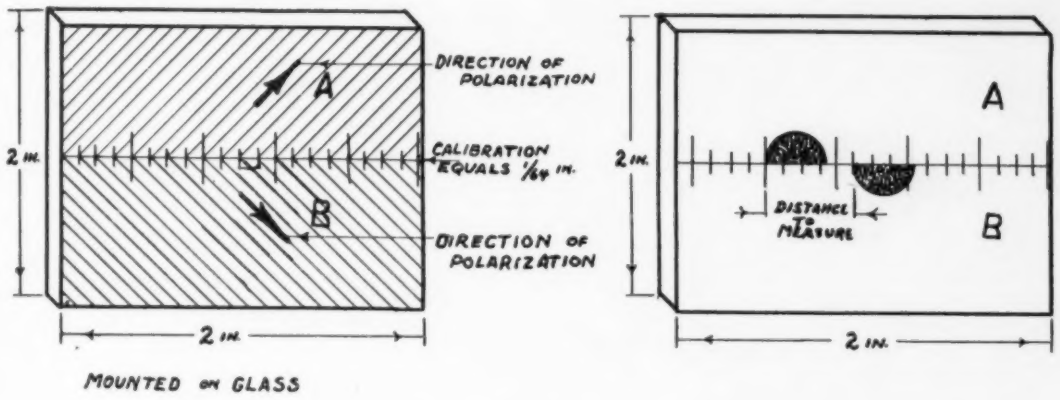


Fig. 9. Polarized ruler.

gions where there is much soft tissue as, for instance, in the thigh. Here the muscle masses are freely movable and compressible, and a reading taken from skin level may be several millimeters out. Instead, a bony landmark should be taken as the base. This landmark, for instance the anterior superior iliac spine, is related to one spoke, the foreign body to another, and the distance between the two is measured, using for determination of each point the polarized ruler described.

Summary. A simple depth grid has been described for the localization of foreign bodies and the determination of spatial relationships.

The method of calculation of depth by means of a polarized ruler has also been described.

The importance of selecting a bony landmark rather than the skin surface for determining the spatial relationship of a foreign body has been pointed out.

2 East 54th St.,
New York, N. Y.

Vol. 49, No. 5

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

Editor: Lawrence Reynolds, M.D. *Assistant Editor:* Ruth Bigelow, B.S.

Editorial Board: A. C. Christie, M.D. E. H. Skinner, M.D. Lauriston S. Taylor
Advisory Board for Pathology: James Ewing, M.D. Eugene L. Opie, M.D.
Collaborating Editors: The Officers and Committee Members of the Societies of which this Journal is the official organ, whose names appear on this page, are considered collaborating editors of this Journal. *Foreign Collaborators:* Gösta Forssell, M.D., Stockholm, G. F. Haenisch, M.D., Hamburg, R. Ledoux-Lebard, M.D., Paris.

Publisher: Charles C Thomas, 220 East Monroe St., Springfield, Illinois.

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich., Office of publication, 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

Officers and Standing Committees

AMERICAN ROENTGEN RAY SOCIETY

President: Ralph S. Bromer, Bryn Mawr, Pa.; *President-Elect*, Sherwood Moore, St. Louis, Mo.; *1st Vice-President:* C. G. Dyke, New York, N. Y.; *2nd Vice-President:* K. D. A. Allen, Denver, Colo.; *Secretary:* H. Dabney Kerr, University Hospital, Iowa City, Iowa; *Treasurer:* J. B. Edwards, 144 Woodridge Place, Leonia, N. J. *Historian:* Ramsay Spillman, New York, N. Y.

Executive Council: Ralph S. Bromer, Sherwood Moore, C. G. Dyke, K. D. A. Allen, H. Dabney Kerr, J. B. Edwards, Lawrence Reynolds, C. M. Richards, S. W. Donaldson, U. V. Portmann, M. C. Sosman, W. M. Doughty, J. C. Dickinson, C. H. Heacock, Bernard P. Widmann, Chairman, 250 South 18th St., Philadelphia, Pa.

Program Committee: B. P. Widmann, Philadelphia, Pa., S. W. Donaldson, Ann Arbor, Mich., H. D. Kerr, Iowa City, Iowa, U. V. Portmann, Cleveland, Ohio, Lawrence Reynolds, Detroit, Mich., Sherwood Moore, Chairman, 510 S. Kingshighway, St. Louis, Mo.

Publication Committee: E. P. Pendergrass, Philadelphia, Pa., J. T. Case, Chicago, Ill., U. V. Portmann, Chairman, Cleveland, Ohio.

Finance Committee: J. C. Peden, St. Louis, Mo., F. B. Bogart, Chattanooga, Tenn., C. M. Richards, Chairman, San Jose, Calif.

Committee on Scientific Exhibits: P. A. Bishop, Philadelphia, Pa., V. W. Archer, University, Va., S. W. Donaldson, Chairman, Ann Arbor, Mich.

Representative on National Research Council: Karl Kornblum, Philadelphia, Pa.

Editor: Lawrence Reynolds, 110 Professional Building, Detroit, Mich.

Assistant Editor: Ruth Bigelow, 110 Professional Building, Detroit, Mich.

Editorial Board: A. C. Christie, E. H. Skinner, Lauriston S. Taylor.

Advisory Board for Pathology: James Ewing, Eugene L. Opie.

Forty-fourth Annual Meeting: 1943, cancelled.

AMERICAN RADIUM SOCIETY

President: William E. Costolow, Los Angeles, Calif.; *President-Elect:* Charles L. Martin, Dallas, Texas; *1st Vice-President:* Frank E. Adair, New York, N. Y.; *2nd Vice-President:* Eugene P. Pendergrass, Philadelphia, Pa.; *Secretary:* A. N. Arneson, 4952 Maryland Ave., St. Louis, Mo. (*Acting Secretary*, E. H. Skinner, 1532 Professional Bldg., Kansas City, Mo.); *Treasurer:* Leland R. Cowan, 606 Medical Arts Bldg., Salt Lake City, Utah.

Executive Committee: Lawrence A. Pomeroy, Chairman, Cleveland, Ohio, Frederick W. O'Brien, Boston, Mass., Hayes E. Martin, New York, N. Y.

Program Committee: Charles L. Martin, Chairman, Dallas, Texas, William S. MacComb, New York, N. Y., Eugene T. Leddy, Rochester, Minn., Herbert E. Schmitz, Chicago, Ill., John S. Bouslog, Denver, Colo.

Publication Committee: E. H. Skinner, Chairman, Kansas City, Mo., Zoe A. Johnston, Pittsburgh, Pa., Wilbur Bailey, Los Angeles, Calif.

Research and Standardization Committee: Edith H. Quimby, Chairman, New York, N. Y., J. L. Weatherwax, Philadelphia, Pa., W. S. MacComb, New York, N. Y.

Education and Publicity Committee: Ernst A. Pohle, Chairman, Madison, Wis., William H. Sargent, Oakland, Calif., Robert B. Taft, Charleston, S. C.

Janeway Lecture Committee: Douglas Quick, Chairman, New York, N. Y., E. H. Skinner, Kansas City, Mo., G. Failla, New York, N. Y., L. A. Pomeroy, Cleveland, Ohio, F. W. O'Brien, Boston, Mass., H. E. Martin, New York, N. Y.

Representatives on American Board of Radiology: Douglas Quick, New York, N. Y., B. P. Widmann, Philadelphia, Pa., F. W. O'Brien, Boston, Mass.

Twenty-eighth Annual Meeting: 1943, cancelled.

EDITORIALS

PYELOGRAMS IN ESSENTIAL OR HORMONAL HYPERTENSION

THE experimental animal studies of Goldblatt[1] and other investigators advanced the theory that renal ischemia is a very important causative factor bringing about hypertension through a hormonal activity of a pressor substance formed in the ischemic kidney. Since then many articles have been written dealing with pyelographic examinations of patients exhibiting so-called essential hypertension in an endeavor to find some changes in the pelvis and calices of one or the other kidney with the hope that in such findings a causative factor of renal ischemia might be removed.

Numerous reports dealing with this subject have occurred in the literature. More recently Shrader, Young and Page[2] undertook a study in an attempt to answer certain questions in the interpretation of retrograde pyelograms of hypertensive patients who showed no evidence of "surgical" renal disease. They posed two questions: first, is there a pyelogram characteristic of hypertensives, and second, is the incidence of abnormal urograms in an unselected group of hypertensives greater than in an unselected group of normotensive controls? In an attempt to answer the first question, they limited their study to patients with normal retrograde pyelograms, as judged by well established criteria, and the retrograde pyelograms of one hundred hypertensive patients were compared with the pyelograms of one hundred normotensive individuals.

[1] Christian, Henry. Osler's Principles and Practice of Medicine. Fourteenth edition. D. Appleton-Century Co., New York, 1942, p. 1127.

[2] Shrader, J. C., Young, J. M., and Page, I. H. Pyelograms in patients with essential and malignant hypertension. *Am. J. M. Sc.*, April, 1943, *205*, 505–514.

Their experience gained from urological studies is that the range of normal variations in urograms is much wider than is usually recognized and that questionable pyelographic variations in normotensives are often disregarded while the same variations in hypertensives are emphasized and, as a result of this overemphasis, the patient becomes a "renal" hypertensive.

Any roentgenologist who has the opportunity of seeing a great number of pyelograms done routinely in a urological department is impressed with the wide variations in urograms not only as regards comparison with individuals but often the same individual will exhibit definite normal variations in the pyelographic appearance of the two sides. Therefore it becomes a matter of great importance in fixing the responsibility of a given kidney in a hypertensive case.

Shrader, Young and Page found that hypertension was not associated with any significant variation in the size of the pelvis to the size of the calices, the general configuration of the pelvis, the pelvic axis or the number or morphology of minor calices. They also found that the incidence of hypertension in patients who exhibited easily recognizable renal abnormalities as demonstrated by retrograde pyelograms was 22 per cent. The incidence of significant renal abnormalities in an unselected group of hypertensives was 19 per cent. The retrograde pyelograms of patients with essential hypertension did not differ significantly from those of normotensives, and the incidence of urographic abnormalities in an unselected group of hypertensives appeared to be no greater than in normotensives.

They call particular attention in their

discussion to the dangers inherent in drawing too conclusive opinions from intravenous pyelograms, quoting the words of Wesson and Ruggles: "One who depends upon intravenous pyelograms alone and does not check the diagnosis by a complete kidney investigation is going to make costly blunders."

Master, Marks and Dack,[3] in summarizing the blood pressure readings in 15,000 men and women over the age of forty, came to the conclusion, as was intimated in a former report of theirs, that the incidence of hypertension in the general population over age forty and fifty is higher than is generally appreciated and since hypertension is common in persons over forty, and with the increase in the number of persons surviving this age, the incidence of hypertension becomes an important question. From an analysis of their studies they conclude that the presence of hypertension at age forty and over is so common that a mild degree and perhaps even a moderate degree can no longer be considered abnormal and that the limits of normal blood pressure at these ages should be raised.

The almost constant postmortem findings of renal arteriolar disease in hypertensive patients dying of renal failure has led to a widespread belief that the renal arteriolar disease is the cause of hypertension, whereas there is another group of observers who believe that the arteriolar disease is secondary to the hypertension, the cause of which is still unknown, and there are some observers[4] who believe that the presence of severe arteriolar damage at the end stage of the disease as seen in autopsy material does not necessarily indicate primary arteriolar disease. The most striking result of the recent investigation by Castleman and Smithwick, in which they secured renal biopsies at the time of sympathectomy in one hundred patients, was the finding of such a high percentage of renal biopsies in which there was no or only minimal vascular disease. They came to the conclusion that the morphologic evidence of renal vascular disease in more than half of their cases was inadequate to be the sole factor in producing the hypertension and that in many of these patients and probably others the hypertensive state antedated the renal vascular lesion. They state that their observations are not in keeping with the concept that renal ischemia due to preexisting renal vascular disease is the cause of essential hypertension in man.

It must be plain that the etiological factor in essential or hormonal hypertension is far from established and that the diagnostic deductions which are made from the retrograde ureteropyelographic examinations must be based upon a complete acquaintance with the widespread differences in pyelographic patterns that obtain in the normal and that too hasty conclusions be not drawn from this study alone.

[3] Master, A. M., Marks, H. H., and Dack, S. Hypertension in people over forty. *J. Am. M. Ass.*, April 17, 1943, *121*, 1251–1256.

[4] Castleman, B., and Smithwick, R. H. Relation of vascular disease to the hypertensive state. *J. Am. M. Ass.*, April 17, 1943, *121*, 1256–1261.

EDWARD GEORGE METER
1876–1943

DR. EDWARD GEORGE METER of Reading, Pennsylvania, suffered a coronary attack on March 18, 1943, and died two days later. He was born April 2, 1876, in Wilkes-Barre, Pennsylvania. After two years of the study of medicine under a preceptor in Hazelton, he entered Medico-Chirurgical College in Philadelphia, receiving his M.D. degree in 1897. He began practice in Williamsport, but moved to Reading in 1898.

Dr. Meter's participation in the practice of roentgenology dates back to 1902, when he took up the study at the Univer-

sity of Pennsylvania, and that year he established the department of roentgenology of St. Joseph's Hospital in Reading. He built much of his own equipment. In 1906 he established the department of roentgenology of the Reading Hospital. His membership in the American Roentgen Ray Society dates back to 1903. In 1941 at a dinner tendered him by the Board of Managers of the Reading Hospital celebrating thirty-five years as head of the department, speakers were his contemporary in the Society, Dr. William S. Newcomet; his senior in the Society by one year, Dr. George E. Pfahler; his junior in the society by twelve years, Dr. Francis F. Borzell, then president of the Pennsylvania Medical Society.

Dr. Meter was also a member of the American College of Radiology and of the Berks County and Pennsylvania Medical Societies and the American Medical Association, and he was a past president of the Philadelphia Roentgen Ray Society. When he retired from the active direction of the department of roentgenology of the Reading Hospital he became chief consultant. In addition to his hospital work he had a large private practice, and he was active also in the medical branch of Civilian Defense. For forty years he was a renowned gardener, and his roses and his rock gardens were celebrated. To commune with Nature was one of his great delights, and he was an able botanist.

He is survived by his wife, Marion King Meter, and three children by a former marriage, William J., Dr. Edward G. Meter, Jr., and Florence Meter DeTurck.

RAMSAY SPILLMAN

The Journal regrets to announce the death, on April 23, 1943, of Dr. Cornelius G. Dyke of New York, distinguished roentgenologist and First Vice-President of the American Roentgen Ray Society.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual Meeting: 1943, cancelled.

American College of Radiology
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual meeting: Chicago, Ill., June 6, 1943.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: 1943, cancelled.

Arkansas Radiological Society
Secretary, Dr. J. S. Wilson, Mack Wilson Hospital, Monticello, Ark. Meets every three months and also at time and place of State Medical Association.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Drake Hotel, Chicago, Ill., Nov. 29–Dec. 3, 1943.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Section on Radiology, California Medical Association
Secretary, Dr. J. D. Coate, 434 Thirtieth St., Oakland, Calif.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

Radiological Section, Los Angeles County Medical Association
Secretary, Dr. Donald R. Laing, 65 North Madison Ave., Pasadena, Calif. Meets on second Wednesday of each month at the County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N.Y. Meets monthly on fourth Tuesday, October to April.

Buffalo Radiological Society
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

Chicago Roentgen Society
Secretary, Dr. Warren W. Furey, 6844 S. Oglesby Ave., Chicago, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. J. O. Newton, 13921 Terrace Rd., East Cleveland. Meets at 6:30 P.M. at Midday Club on fourth Monday each month, October to April, inclusive.

Denver Radiological Club
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Building.

Florida Radiological Society
Acting Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Fla. Meetings in May and November.

Georgia Radiological Society
Secretary, Dr. James J. Clark, 478 Peachtree St., Atlanta, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

Radiological Society of Kansas City
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month at a place designated by the president.

Illinois Radiological Society
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

Indiana Roentgen Society
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meeting held the second Sunday in May annually.

Kentucky Radiological Society
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

Louisiana Radiological Society
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

Michigan Association of Roentgenologists
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

Minnesota Radiological Society
Secretary, Dr. Annette T. Stenstrom, 1218 Medical Arts Bldg., Minneapolis, Minn. One meeting a year at time of Minnesota State Medical Association.

Nebraska Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. Hugh F. Hare, Lahey Clinic, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. H. J. Perlberg, 921 Bergen Ave., Jersey City. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

New York Roentgen Society
Secretary, Dr. M. M. Pomeranz, 1020 Park Ave., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

North Dakota Radiological Society
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Ohio Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport. Annual meeting, Brunswick Hotel, Lancaster, Pa., May 15–16, 1943.

Philadelphia Roentgen Ray Society
Secretary, Dr. R. P. Barden, University Hospital, Meetings first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Pittsburgh Roentgen Society
Secretary, Dr. R. G. Alley, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Sidney Larson, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

Rocky Mountain Radiological Society
Secretary, Dr. A. M. Popma, 220 N. First St., Boise, Idaho.

St. Louis Society of Radiologists
Secretary, Dr. P. C. Schnoebelen, 462 N. Taylor Ave. Meets fourth Wednesday of each month, except June, July, August, and September, at a place designated by the president.

San Francisco Radiological Society
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

Shreveport Radiological Club
Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. Herman Klapproth, Sherman, Texas.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St., Richmond, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday each month, College Club, Seattle.

X-ray Study Club of San Francisco
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

Canadian Association of Radiologists
Secretary, Dr. A. D. Irvine, 540 Tegler Bldg., Edmonton, Alberta.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse Biel. Meets annually in different cities.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad: USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

FIRST INTER-AMERICAN CONGRESS OF RADIOLOGY

The First Inter-American Congress of Radiology is to meet in the Buenos Aires School of Medical Sciences, in October, 1943. *Chairman*, José F. Merlo Gómez, M.D., President of Sociedad Argentina de Radiología; *Secretary*, Oscar F. Noguera, M.D.; *Treasurer*, Manuel F. Terrizzano, M.D.

Purpose. The First Inter-American Congress of Radiology will fulfill a desire which we believe has been entertained by radiologists throughout the Americas. Its sole purpose is to bring together men of science so that they may interchange ideas and tighten friendship bonds.

Radiology occupies an outstanding place within the conception of the unity of medicine. To the era of empiricism of its beginning has followed the present era of progress in which subjects are discussed and dealt with under the brilliant light of truth, of sincerity, for the love of one's neighbor, with the advancement of radiology as a goal.

We meet for this purpose. To this end we are to convene in the First Inter-American Congress of Radiology.

Program. Since the First Inter-American Congress of Radiology will take place some months hence, it is obvious that no final program can be worked out at this time.

Members. In accordance with the general regulations, persons attending the Congress will be registered as members or associate members.

Radiological societies throughout the Americas and, in the lack thereof, professors of radiology or related subjects, heads of radiological departments and associates holding their positions over three years, will be members of the First Inter-American Congress of Radiology. (Although such membership requirements may seem restrictive, their purpose is to induce radiologists to unite into radiological societies—where such societies do not exist—so as to have the opportunity of interchanging ideas and seeking the advancement of their specialty.)

The following will be registered as associate members:

(a) Physicians, physicists, and manufacturers of electromedical apparatus, upon request.

(b) Relatives of members (their wives, sons under eighteen, and single daughters), three such relatives being the limit.

Traveling. To facilitate traveling and lodging to members of the Congress "Exprinter" has been appointed official agency for such purpose, for taking care of customhouse requirements and of such matters as insurance, currency exchange, etc.

Reception. Upon their arrival in Buenos Aires, provided they have announced it, members of the Congress will be met by authorized persons who will tell them how they may reach their lodging place.

Subjects for Discussion.

1. Roentgen diagnosis of diseases of the spine.
2. Cancer of the breast. Treatment and results.
3. Roentgen diagnosis of diseases of the intestine: (*a*) inflammatory jejunoileal affections, (*b*) inflammatory affections of the colon.
4. The teaching of radiology in the Americas.

Visits to Radiological Departments. Several visits will be made in the mornings to radiological departments of the Buenos Aires hospitals. Roentgenograms will be shown, explained and commented on by the department heads during such visits.

Correspondence. Correspondence regarding the Congress should be addressed to Secretaria General del 1er Congreso Interamericano de Radiologia, Alsina 3117, Buenos Aires, Argentina.

MINNESOTA RADIOLOGICAL SOCIETY

Due to the present world conditions, the Minnesota Radiological Society has had no

meetings this year. At the Fourteenth Annual Meeting held in Duluth in conjunction with the Minnesota State Medical Association the following officers were elected: Dr. Arthur U. Desjardins, Rochester, *President;* Dr. John R. McNutt, Duluth, *Vice-President,* and Dr. Annette T. Stenstrom, Minneapolis, *Secretary-Treasurer.* It was decided to hold one meeting a year in conjunction with the meeting of the Minnesota State Medical Association.

AN AID IN CHOLECYSTOGRAPHY

To the Editor:

One of the difficulties encountered in oral cholecystography is the overlying hepatic flexure of the colon, filled either with gas or iodine salts, or both. The use of enemas or drugs is not always successful or desirable in remedying this. Roentgenograms in the erect posture are sometimes successful in separating the vesica fellea from the gut, but this method is not routine in many offices.

I have experimented for some time and have finally succeeded, I believe, in devising a simple and comfortable method to separate the two organs. The preliminary enema is not necessary. One end of an air-filled rubber bag or a hemisphere of balsa wood about 4 inches high is placed under the inferior right costal margin. With the patient prone this displaces the gallbladder upward and the colon downward about 3 to 4 centimeters. While I have not had any personal experience it may well be that small calculi or polyps not visualized by the old method can be seen more easily.

I have had only ten cases in which it was necessary to use this method but in all of them it was simple and easy to displace the gallbladder above the colon, thus making possible a more definite diagnosis.

George Rosenbaum, M.D.

1521 Spruce St.,
Philadelphia, Pa.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

INTESTINAL OBSTRUCTIONS: A PHYSIOLOGICAL AND CLINICAL CONSIDERATION WITH EMPHASIS ON THERAPY; INCLUDING DESCRIPTION OF OPERATIVE PROCEDURES. By Owen H. Wangensteen, B.A., M.D., Ph.D., Professor of Surgery of the University of Minnesota and Surgeon-in-Chief of the University of Minnesota Hospital. Second Edition. Cloth. Price, $7.00. Pp. 484, with 143 illustrations. Springfield, Illinois: Charles C Thomas, 1942.

This book which was first published in 1937 has just appeared in its second edition. The first volume which was an outgrowth of the Samuel D. Gross Prize Award was published under the title "The Therapeutic Problem in Bowel Obstruction." It was enthusiastically received by the medical profession and at once became the standard reference work on the subject of intestinal obstruction. The new volume has been largely rewritten and extensively revised and contains much new material with appropriate illustrations. The work is conveniently divided into four main sections dealing with the following: (1) the fundamental problems of pathological physiology involved in bowel obstruction; (2) the diagnosis of intestinal obstruction; (3) the methods of treatment; (4) the special types of obstruction.

In Part I the author discusses such matters as the mechanisms by which the bowel becomes distended; the nature and source of the contents of the obstructed bowel; the significance of the ileocecal sphincter; the extent of intraenteric pressure and distention upon the bowel wall, the blood supply of the intestine and upon the circulation in general; the consequences of fluid loss and the importance of loss of blood into infarcted intestinal segments in the strangulation obstructions.

Part II consists of a review and summary of the evidence upon which the diagnosis of obstruction rests. The writer discusses the importance of the presence or absence of intestinal colic and of vomiting and the significance of vomiting in small and large bowel obstruction. The roentgen examination is considered in detail and also interpretation and correlation of the roentgen findings with the clinical data. By these several examinations, he believes that it is possible to determine whether obstruction is present, whether it is complete or incomplete, whether the colon or the small intestine is involved and in the latter case whether the obstruction is in the upper, middle or lower portion and finally whether the obstruction is of the simple or strangulation type.

Part III is concerned with the various forms of treatment. Since operation is the mainstay in therapy, the principles and technical features of the acceptable operations are described. The choice of the operative procedure as governed by the character of the obstruction is considered and those obstructions requiring immediate operation are discussed. Considerable space is devoted to the relief of simple mechanical obstruction especially when not complete by suction without operation. Evidence is presented to show a decrease in the incidence of postoperative obstruction consequent upon the more general use of suction during the postoperative period. The indications and contraindications for the use of suction are given and the limitations and shortcomings of this method of treatment are outlined.

One of the most valuable features of the book is the fact that the solution of clinical problems pertaining to the diagnosis and treatment of intestinal obstruction is based upon the important fundamental basic principles of physiology, pathology and chemistry. While abundant use is made of the facts obtained from the basic sciences and from experimental surgery, the book is essentially clinical in character and is designed for the practitioner of surgery rather than for the laboratory worker. In addition to the management of obstructions *per se* adjuvant forms of therapy, e.g., the use of high concentrations of oxygen for distention, the maintenance of fluid nitrogen and electrolyte balance and chemotherapy are dealt with according to their importance. The various surgical procedures are carefully described and well illustrated. Excellent descriptions are given of the aseptic anastomoses long championed by the author

and of the use of the special clamps for this purpose devised by him. The author's personal views concerning certain aspects of the problem are in evidence. Thus, he condemns cecostomy for the relief of acute obstructions of the colon and feels that aseptic transverse colostomy is far superior. He believes that postoperative obstruction at the gastroenteric stoma in gastric resections or gastroenterostomies is almost always the result of technical errors and oversuturing rather than being due to such general causes as hypoproteinemia. With this statement the reviewer is in full accord. The author's method in use at the University of Minnesota Hospital for determining the state of hydration by daily determination of the weight of the patient is presented. When local intraperitoneal implantation of a sulfonamide drug is indicated the author prefers sulfathiazole. In his experience this has proved superior to sulfanilamide.

The use of the Miller-Abbott tube is discussed in some detail and its theoretical advantages elucidated. One of the benefits commonly ascribed to the "long" Miller-Abbott tube is its use in decompression of the intestine prior to resections of the colon. The author's belief that equally good results may be achieved by gastroduodenal suction is shared by many others. While the author was responsible for popularizing gastroenteric suction as a form of therapy, its place, scope and limitations are well defined and operative and non-operative measures are impartially considered. In the opinion of the writer the greatest advances in the future will be in the perfection of surgical procedures whereby the distended bowel may be safely decompressed at operation without peritoneal soiling.

This monograph should occupy an important place in the library of resident surgeons and young surgeons beginning practice and it should also be of inestimable value to the experienced surgeon or any who have occasion to engage in abdominal surgery.

Frederick A. Coller

Roentgen Interpretation. By George W. Holmes, M.D., Roentgenologist to the Massachusetts General Hospital and Clinical Professor of Roentgenology, Harvard Medical School, and Howard E. Ruggles, M.D., Late Roentgenologist to the University of California Hospital and Clinical Professor of Roentgenology, University of California Medical School. Sixth edition, thoroughly revised. Cloth. Price, $5.00. Pp. 364, with 246 illustrations. Philadelphia: Lea & Febiger, 1941.

"Roentgen Interpretation" needs no introduction to older roentgenologists. They have long known it as an excellent text for teaching medical students and for the guidance of those entering the speciality of radiology. The older roentgenologists have known Holmes and Ruggles as pioneers and leaders of their profession, long recognized as leading teachers and living proof of their success in the number of well trained men representing them all over the country. In its sixth edition this book still occupies a leading place among roentgen texts. Earlier editions were written with such insight into fundamentals and such a knowledge of the subject that one is impressed by the many paragraphs which are just as applicable today as they were in previous years. Of course the object of the new edition is to bring the material up to date and this has apparently been done. The book is elementary in its scope but covers the field satisfactorily. It is well written and well arranged and illustrations are plentiful and interesting. Older roentgenologists should enjoy reviewing this new edition. Younger roentgenologists need its help and will find it a firm basis for their roentgen knowledge and will use it for frequent reference. The latter cannot afford to omit this classic text from their library.

E. Walter Hall

Die Deutung des Röntgenschichtbildes der Longenspitzen bei Lungentuberkulose. Von Dr. Wilhelm Kremer, Ärztlicher Direktor der Heilstätten Beelitz und des Tuberkulosekrankenhauses Beelitz (Mark), und Dr. Leonore Retzlaff, Assistenzärztin der Heilstätten Beelitz. Cardboard. Price, RM. 3.60. Pp. 43, with 46 illustrations. Leipzig: Georg Thieme, 1941.

The interpretation of the tomogram of the lungs is not easy and the differentiation between normal blood vessel shadows and cavities is often difficult. The authors undertook, therefore, a comparative study of the tomograms of patients with small lesions in the apex and sections of the fixed lungs prepared after the patient's death; they used the method described by Aschoff. Observations carried out on 5 cases showed that with a pendulum angle of 30 de-

grees the tomograms included a tissue layer of approximately 1.5 cm. in thickness. All foci of pea size could be demonstrated. Cavities in well aerated lung parenchyma of over 1 cm. in diameter are easily seen, also bronchi with thickened walls, emphysematous bullae and bronchiectasis. Some of the diagnostic pitfalls are caused by the anterior arch of the first rib which may simulate a tuberculous infiltration, and also by cross sections of blood vessels which might be mistaken for tuberculous foci. Not every ring-like shadow represents a tuberculous cavity but may be caused by a cyst, bronchiectasis or an emphysematous bulla. With increasing experience the authors believe that tomograms of the lungs can show a picture which corresponds closely to the underlying pathological anatomical process. The illustrations accompanying the text are very instructive and are well worth studying in detail.

Ernst A. Pohle

X-Ray Therapy of Chronic Arthritis (Including the X-Ray Diagnosis of the Disease): Preliminary Report Based on 100 Patients Treated at Quincy, Illinois. By Karl Goldhamer, M.D., Associate Roentgenologist, St. Mary's Hospital and Quincy X-Ray and Radium Laboratories; Formerly Roentgenologist, University of Vienna. With a Foreword by Harold Swanberg, B.S., M.D., F.A.C.P., Editor *Mississippi Valley Medical Journal and the Radiologic Review;* Roentgenologist, St. Mary's Hospital and Blessing Hospital, etc. Cloth. Price, $2.00. Pp. 131, with 26 illustrations. Quincy, Illinois: Radiologic Review Publishing Co., 1941.

In this monograph the author relates his experience with the treatment of 100 private patients with chronic arthritis by roentgen rays observed during a period of twenty-one months. He covers the clinical and pathologic aspects of the atrophic and hypertrophic types of chronic arthritis, the roentgen findings, differential diagnosis and the history of roentgen therapy in this disease. He believes that the mechanism of effect is in all probability due to the production of hyperemic stimuli by the irradiation. The indications for and the technique of the treatment are outlined in detail. A table gives in condensed form information regarding age, sex, duration of disease, clinical diagnosis, treated region, roentgen diagnosis and dosage of roentgen radiation. The statistical analysis of the material presented shows that satisfactory results were obtained in about 60 per cent of all patients; the chief benefit was the relief of pain. The author cautions against excessive dosage which would be followed by undesirable sequelae. In conclusion he states that "although the results obtained by us are favorable indeed in a majority of patients (60 per cent), they are not entirely satisfactory because a considerable percentage (40 per cent) are not benefited, or are only slightly benefited, by x-ray therapy. Perhaps when this method of treatment becomes better known and when more physicians become familiar with it and will use it, better results will be obtained."

Ernst A. Pohle

BOOKS RECEIVED

The Periodicity and Cause of Cancer, Leukaemia and Allied Tumours: With Chapters on Their Treatment. By J. H. Douglas Webster, M.D., F.R.C.P.E., F.F.R., Honorary Director, Meyerstein Institute of Radiotherapy, Middlesex Hospital, London; Lecturer and Examiner in Radiology, University of London, etc. Cloth. Price, $3.50. Pp. 178, with 5 plates. London: Baillière, Tindall and Cox; Baltimore: Williams & Wilkins Co., 1940.

The Electrocardiogram and X-Ray Configuration of the Heart. By Arthur M. Master, B.S., M.D., F.A.C.P., Cardiologist to the Mt. Sinai Hospital, New York; Assistant Professor of Clinical Medicine, Columbia University, New York. Second edition, enlarged and thoroughly revised. Cloth. Price, $7.00. Pp. 404, with 163 illustrations, Philadelphia: Lea & Febiger, 1942.

Clinical Roentgenology of the Cardiovascular System. By Hugo Roesler, M.D., F.A.C.P., Associate Professor of Roentgenology and Cardiologist, Department of Medicine, Temple University School of Medicine; Cardiologist, Temple University Hospital, Philadelphia, Pennsylvania. Second edition. Cloth. Price, $7.50. Pp. 480, with 337 illustrations. Springfield, Illinois: Charles C Thomas, 1943.

Oleoperitoneografía: Contribución al estudio radiológico del peritoneo. Por los doctores Prof. Carlos H. Niseggi, Professor Adjunto de Radiología de la Facultad de

Medicina de Bs. Aires; Jefe del Servicio Central de Radiología del Hospital Teodoro Alvarez; Miembro Fundador de la Sociedad Argentina de Radiología, Marcelo H. Moreau, Médico Agregado del Servicio Central de Radiología del Hospital Teodoro Alvarez; Miembro Titular de la Sociedad Argentina de Radiología, and Jorge E. Moreau, Médico Interno del Instituto Municipal de Radiología y Fisioterapia. Paper. Pp. 197, with 153 illustrations. Buenos Aires: Libreria y Editorial "El Ateneo," 1941.

NEUROLOGY. By Roy R. Grinker, M.D., Chairman, The Department of Neuropsychiatry of the Michael Reese Hospital, Chicago. Third edition. Revised and largely rewritten. With the Assistance of Norman A. Levy, M.D., Associate Neuropsychiatrist, Michael Reese Hospital, Chicago. With a Chapter on Brain Tumors by Paul C. Bucy, M.D., Professor of Neurology and Neurological Surgery, University of Illinois, College of Medicine, Chicago. Cloth. Price, $6.50. Pp. 1136, with 416 illustrations. Springfield, Illinois: Charles C Thomas, 1943.

A BIBLIOGRAPHY OF AVIATION MEDICINE. By Ebbe Curtis Hoff and John Farquhar Fulton. Prepared for the Committee on Aviation Medicine, Division of Medical Sciences, National Research Council, Acting for the Committee on Medical Research, Office of Scientific Research and Development, Washington, D. C. Cloth. Price, $4.00. Pp. 237. Springfield, Illinois: Charles C Thomas, 1942.

WAR GASES: THEIR IDENTIFICATION AND DECONTAMINATION. By Morris B. Jacobs, Ph.D. Food, Drug and Insecticide Admin. U. S. Dept. of Agr. 1927; Chemist Department of Health, City of New York, 1928; Formerly, Lt. U. S. Chemical Warfare Service Reserve. Cloth. Price, $3.00. Pp. 180, with 8 illustrations and numerous tables. New York: Interscience Publishers, Inc., 1942.

RENAL LITHIASIS. By Charles C. Higgins, M.D., Cleveland Clinic, Cleveland, Ohio. Cloth. Price, $3.00. Pp. 140, with 18 illustrations. Springfield, Illinois: Charles C Thomas, 1943.

TRANSURETHRAL PROSTATECTOMY. By Reed M. Nesbit, M.D., F.A.C.S., Associate Professor of Surgery, University of Michigan Medical School, in charge of the Section of Urology, Department of Surgery. With a Chapter on the Vascular Supply of the Prostate Gland by Rubin H. Flocks, M.D. Cloth. Price, $7.50. Pp. 192, with 62 plates including 94 original drawings by William P. Didusch. Springfield, Illinois: Charles C Thomas, 1943.

SELECTED PAPERS FROM THE ROYAL CANCER HOSPITAL (FREE) AND THE CHESTER BEATTY RESEARCH INSTITUTE. Vol. 1. 1935–1939. Paper. Price, 16/-. Pp. 484, with numerous illustrations. London: Royal Cancer Hospital (Free).

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Head

BENDA, C. E. Observations on the malformation of the head in mongoloid deficiency.. 705

HOWES, W. E., and BERNSTEIN, L.: Oral carcinoma..... 705

DIGBY, K. H., FOOK, W. L., and CHE, Y. T.: Nasopharyngeal carcinoma..... 706

GROSS, S. W.: Cerebral arteriography with diodrast..... 706

REES-JONES, G. F., and MCGIBBON, J. E. G.: Radiological visualization of the eustachian tube..... 706

GRIER, G. W.: Nasal sinusitis..... 707

Neck and Chest

POWERS, R. A., and STARKS, D. J.: Acute (primary) coccidioidomycosis..... 707

RITTERHOFF, R. J.: Acute silicosis occurring in employees of abrasive soap powder industries..... 708

LEMON, W. S.: Factors involved in production and development of silicotic lesions..... 708

CLEMENT, G.: Silicosis..... 708

APFELBACH, G. L., and CARTER, J. B.: Recurrent postoperative atelectasis..... 708

FARBER, J. E.: Bronchial stenosis and unexpandable lungs..... 709

JACINTO, C. P., and LAHOZ, M.: "Reversible" and "irreversible" massive pulmonary atelectasis..... 709

ISRAEL, H. L., and LONG, E. R.: Primary tuberculosis in adolescents and young adults 709

ACKERMAN, L. V., and KASUGA, K.: Chronic cor pulmonale..... 710

KOERTH, C. J., DONALDSON, J. M., JR., and MCCORKLE, R. G.: Bronchomoniliasis... 711

SINGER, J. J., and TRAGERMAN, L. J.: Lipoid pneumonia..... 711

THOMAS, A. R.: "Blast chest"..... 712

CRIMM, P. D., COOKSON, H. N., and BROADBENT, M.: Patch and PPD tests and x-ray correlation..... 712

GOWAR, F. J. S.: Post-operative complications of pulmonary lobectomy..... 713

GENGENBACH, F. P., and DOBOS, E. I.: Congenital tracheoesophageal fistula..... 713

SACHS, M. D.: Carcinoma of male breast..... 713

KORNBLUM, K., and BRADSHAW, H. H.: Intrathoracic neurogenic tumors..... 714

ODESSKY, I. N.: Roentgen diagnosis of neurinoma of thorax..... 715

MCGIBBON, J. E. G., and BAKER-BATES, E. T.: Bronchoscopic clinic..... 715

DOUGLAS, B. H., and BIRKELO, C. C.: Miniature x-ray film of the chest..... 715

FAULKNER, W. B., JR., RODENBAUGH, F. H., and O'NEILL, J. R.: Influence of emotions upon esophageal function..... 715

Abdomen

DAVIDSON, S. W., and ROSE, J. D.: Value of cooperation between radiologist and gastroscopist..... 716

TAYLOR, H.: Practical evaluation of gastroscopy..... 716

WHITE, J. D.: Unusual sequel to gastroscopy.. 717

COLMERS, R. A.: Parasternal diaphragmatic hernia with report of case on right side... 717

DELANO, P. J., RONAYNE, F. J., and BOLAND, T. B.: Rectal dyschezia..... 717

WASSON, W. W.: Study of gastrointestinal tract of children and its relation to the adult... 718

RITVO, M., and MCDONALD, E. J.: Gastrocolic fistula..... 718

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

Benda, C. E. Observations on the malformation of the head in mongoloid deficiency. *J. Pediat.*, Dec., 1941, *19*, 800–816.

Mongolism is a fetal disease, occurring in many gradations. It is not a malformation. Many newborn mongolian infants are not recognized due to lack of typical appearance; 2.3 mongoloids occur in every 1,000 births. Mongolism is present in 6 to 10 per cent of mental defectives.

The accepted stigmata of mongolism are epicanthal folds, slanting palpebral fissures, fissured lips and tongue, short hands with curved little fingers, short feet with a gap between first and second toes, stout figure, hypotony, strabismus, deep voice and a typical psychologic behavior. The author has concluded, after a study of 300 mongoloids and 31 autopsies, that the mongoloid appearance is due to growth disorder of the skull. The skull malproportion is only part of a general growth disorder.

In the mongoloid skull the sphenoid body is either upright or bent backward instead of forming its normal angulation with the clivus. The floor of the anterior fossa is steep. The cribriform plate is shorter and lies at a higher level. Failure of development of the facial bones results in persistence of the fetal proportions of the face. The nasion is retracted and the maxilla and mandible underdeveloped. The closure of the fontanelles is delayed. The bones of the skull remain thin and ossification of sutures is delayed or absent. Lack of growth of the spheno-occipital and spheno-ethnoidal synchondroses results in shortening of the base of the skull.

The entire skeleton is involved in the growth disturbance. The length of the metacarpals and phalanges is reduced. Incurving of the little fingers is characteristic.

The delayed growth is now supposed to be due to lack of a specific growth factor, probably from the anterior lobe of the pituitary gland.

The author suggests the term "congenital acromicria" for mongoloid deficiency.—*R. M. Harvey.*

Howes, William E., and Bernstein, Louis. Oral carcinoma. *Radiology*, Oct., 1941, *37*, 468–475.

The authors report 138 cases of cancer of the mouth treated at the Brooklyn Cancer Institute; only 111 are considered in the tabulations as the data were insufficient in the other 27.

Because of the anatomical structure of the mouth with the mucosa in close relation to bone muscles and lymphoid tissue, these cancers develop rapidly and metastasize quickly. Of the authors' cases 63, or 56.8 per cent, were in Stage IV, and only 1, or 0.9 per cent, in Stage I. The patients rarely report for treatment until they have pain from ulceration and infection.

Forty-nine cases, or 44.2 per cent, were in the tongue. They were treated by radium implantation followed by roentgen therapy. The details of the technique are given. Eight of these cases, or 16.3 per cent, were clinically controlled at the time of writing, 1 less than a year after treatment, the rest more than a year and 1 seven years. Of the 16 cases with cancer of the floor of the mouth 2 are alive with the lesions controlled four years after treatment. Three are alive with the disease still active and the others have died. The cases in this series were treated with external irradiation only. A more recent series treated by contact irradiation with the Chaoul type of apparatus seem to be giving better results. All of the 7 patients with cancer of the alveolar ridge are dead, 4 within one year or less, 1 within eighteen months, 1 in two years and 1 in one and a half years. All of the 6 patients who had cancer of the mucous membrane of the cheek are dead, 4 within a year and the other 2 within eighteen months. The 14 patients with cancer of the palate were treated by direct irradiation through an intraoral cone. Seven of these patients are still alive, 2 with evidence of cancer, 5 clinically well after eight months, 1 and a half years, two and a half years, three years and nine years. Only 3 of the 19 cases of cancer of the tonsil appear to be clinically controlled. Two of them have been followed less than two years and 1 just under one year.

Further study is needed to improve methods of radiation treatment.—*Audrey G. Morgan.*

Digby, K. H., Fook, W. L., and Che, Y. T. Nasopharyngeal carcinoma. *Brit. J. Surg.*, April, 1941, *28*, 517–537.

Apparently, judging from the literature, carcinoma of the nasopharynx is not common in other countries, but it is very common in China. Figures from Hong Kong show that it ranks second only to carcinoma of the cervix in number of cases. The only plausible theory to account for this frequency is that of Dobson who says that it is due to irritation from the soot in the small houses which are not ventilated. This hypothesis, however, seems inconsistent with the fact that the disease is much more frequent in men than in women, as women spend more time in the house. Unlike other cancers, this type occurs more frequently before the age of forty than after forty. The age groups in which it is most frequent are those from thirty-one to thirty-five and thirty-six to forty.

The article is profusely illustrated with photographs of patients and photomicrographs of the histopathological findings. The symptoms are extremely varied as the origin of the tumor is near the center of the head and the ear, nose and orbit and all of the cranial nerves and the cervical sympathetic may be affected. The commonest symptom is enlargement of the cervical glands and this is often thought to be syphilitic or tuberculous, and in fact either of these diseases may coexist with nasopharyngeal carcinoma. The association with tuberculosis is particularly frequent because of the appalling prevalence of tuberculosis in Hong Kong. These tumors probably originate from the columnar epithelium lining the upper part of the nasopharynx.

The duration of the disease varies from three months to five years or more without treatment. Treatment has not proved very successful. Owing to the anatomical relations surgery is difficult or impossible. Radium treatment with needles has been tried in 82 cases with some improvement in all; the glands rapidly decrease in size and often disappear but recurrence takes place within six months. No radium bomb has been available for treatment. Deep roentgen treatment would seem to be more hopeful but the authors have not had time to evaluate the results of their deep roentgen therapy. One case at least has proved entirely refractory to this treatment.—*Audrey G. Morgan.*

Gross, Sidney W. Cerebral arteriography with diodrast, fifty per cent. *Radiology*, Oct., 1941, *37*, 487–488.

Diodrast (3, 4-diiodo-4-pyridon-N-acetic acid diethanolamine) has been used for years for intravenous pyelography and more recently for visualization of the heart and great vessels. When it was first tried for cerebral arteriography a 70 per cent solution was injected into the common carotid artery. This caused jacksonian convulsions but when a 35 per cent solution was used good visualization of the cerebral circulation was not obtained.

It has now been found that a 50 per cent diodrast solution gives good visualization without any ill effects. The common carotid artery is isolated from the surrounding structures by passing a narrow vaseline tape under it. The patient's head is put in position for a lateral roentgenogram. The carotid is punctured with a No. 17-gauge needle with a rubber connection. A syringe containing 15 cc. of the solution is attached to the rubber connection and 10 to 12 cc. of the solution injected as rapidly as possible, the film being exposed during the injection. Illustrative arteriograms are given.—*Audrey G. Morgan.*

Rees-Jones, G. F., and McGibbon, John E. G. Radiological visualization of the eustachian tube. *Lancet*, Nov. 29, 1941, *2*, 660–662.

The authors, who are radiologist and aurist at the Royal Air Force Hospital, describe and illustrate their technique for visualizing the eustachian tube. They have used this method only in the examination of the form of deafness that occurs on rapid loss of altitude in flying. The eustachian tube may be regarded as consisting of two cones united at their apices. The outer cartilaginous one is about 24 mm. long and the inner bony one about half as long. The narrowest point in the lumen is where the apices of the two cones join. Here it measures only about 2 by 1 mm.

The opaque medium is introduced through a eustachian catheter passed through the anesthetized nasal fossa and a tympanic catheter pushed through it until it reaches an obstruction. Pyelectan has been found the best medium. Iodized oil is too viscous to pass through the tympanic catheter. In this type of deafness there is a definite block in the cartilaginous part of the tube. Among the authors' 34 cases it was found in 2 at the isthmus, in 1 at 0.5 cm. from the pharyngeal orifice and in the other 31 at 1

to 2 cm. from the ostium. In these latter sites the pooling of the opaque medium gives mushroom-like shadows.—*Audrey G. Morgan.*

Grier, G. W. Nasal sinusitis. *Radiology*, Dec., 1941, *37*, 659–665.

The roentgen findings in acute and chronic sinusitis and malignant growths involving the sinuses are discussed and illustrated with roentgenograms. Acute catarrhal sinusitis is probably not often recognized because there is little occasion to make roentgen examination of the sinuses in these cases. The author believes that roentgen examination of hay fever patients would show a large percentage of opaque sinuses. In acute suppurative sinusitis the maxillary sinus is most frequently involved though the ethmoid cells or frontal sinus may be affected. The affected cavity appears as a dense uniform shadow. In acute fulminating sinusitis the roentgen diagnosis is complicated by swelling and edema of the soft tissues, which may persist after the cavity is drained and arouse doubt as to whether the pus has been evacuated completely.

In chronic suppurative sinusitis there are confusing factors, such as thickened membranes without sinusitis, that make a history of the case necessary to interpretation of the films and there should be the closest collaboration between rhinologist and roentgenologist. In chronic hyperplastic sinusitis the characteristic findings are caused by the marked edema and swelling of the mucous membrane. The diagnosis depends on the recognition of thickened membrane, polypi or cysts. There are three roentgen signs of polypi: (1) comparatively large, smooth round or pear-shaped discrete shadows; (2) a very thick membrane due to polypoid degeneration; (3) a decided widening of the ethmoid region caused by distention of the ethmoids by the many polypoid growths. In malignant growths diagnosis is based on changes in the surrounding bone rather than any characteristic appearance of the sinuses.

The superior-inferior view is absolutely necessary for visualizing the sphenoid sinus. It does not matter particularly whether it is made from below upward or from above downward. The author prefers to make it from above downward, usually with a Bucky diaphragm. In his routine examination he includes the Granger position. With the patient lying down any pus in the sphenoid gravitates toward the roof. The patient is put on his stomach and the head tilted 17° beyond the horizontal. The shadow of the sphenoid is thrown into the area between the frontals just above the bridge of the nose, and the Granger line, which is the roof of the sphenoid, is seen. If there is pus in the sphenoid this sharp line is not seen.—*Audrey G. Morgan.*

NECK AND CHEST

Powers, Robert A., and Starks, Dorothy J. Acute (primary) coccidioidomycosis: roentgen findings in a group "epidemic." *Radiology*, Oct., 1941, *37*, 448–453.

So-called "valley fever" has long been familiar to the residents of San Joaquin Valley. It is caused by infection with the fungus *Coccidioides immitis* and is usually acquired by inhaling dust which contains the spores. It may occasionally be caused by infection through a skin wound. It is not transmitted from person to person.

In the acute stage the symptoms resemble those of influenza or bronchopneumonia. The second stage shows erythema nodosum, arthritis and conjunctivitis. The clinical diagnosis is made by the finding of typical double-contoured spherules in the sputum, a positive coccidioidin reaction, appearing not earlier than the twenty-sixth day in the authors' group, positive agglutination tests, animal inoculation, leukocytosis and eosinophilia. In a series of acute cases studied in California the fatal granulomatous form developed in only one, in this case in the form of meningitis.

The authors had an opportunity to make roentgen examinations in a group of 7 students who acquired the infection on a field trip to an endemic region. The cases are described and illustrated with roentgenograms. Generally the lesions are solitary or few in number and consist of spherical opaque areas with a peripheral distribution. They are usually opposite or posterior to the hilum, in the lower part of the upper lobe or the upper part of the lower lobe. The findings resemble those of pneumonia or primary tuberculosis. In the few cases with multiple lesions the picture may resemble that of cancer. It is doubtful whether acute coccidioidomycosis can be diagnosed by roentgen examination alone but the findings may be characteristic enough to suggest the right diagnosis which may be confirmed by finding eosinophilia, spherules in the sputum and later the positive coccidioidin test and agglutination reaction.—*Audrey G. Morgan.*

RITTERHOFF, R. J. Acute silicosis occurring in employees of abrasive soap powder industries. *Am. Rev. Tuberc.*, Jan., 1941, *43*, 117–131.

Acute silicosis has been reported for various types of abrasive contacts though very few have been employed in soap factories. The author is reporting 2 cases in soap workers.

The exposure times for these 2 cases were one hundred days and twelve months, respectively —much less than the duration of contact for cases of similar type. The duration of life following recognition of the disease was longer than reported for these other cases, it being four years as an average for the 2 cases.

The factor of alkalinity is mentioned as possibly explaining the rapidity in development of the fibrosis.

When tuberculosis occurs in this type of case it has usually been of the exudative caseous type.

"Metastatic" silicotic lesions were found in 1 of the 2 cases. These are described as "foci of macrophages which do not show the typical histology of silicotic nodules and may be areas of reticulo-endothelial hyperplasia rather than true metastasis."

One of the 2 cases showed a cor pulmonale—as in 3 of 9 similar cases reported in the literature—apparently not an infrequent complication which is most prone to develop in cases having areas of massive fibrosis and marked emphysema.—*A. A. de Lorimier.*

LEMON, WILLIS S. Factors involved in the production and development of silicotic lesions. *Radiology*, Oct., 1941, *37*, 413–420.

The author describes silicosis produced by the introduction of silica dust into the lungs of rabbits by intubation or by its intraperitoneal injection. No other dusts are so damaging as silica. The reaction between the particles of silica and the tissue cells results in fibrosis. Fibrosis is brought about by arrest of the phagocytes after the particles have been phagocytosed. The formation of the fibrous nodule represents an effort on the part of the body to segregate and encapsulate the noxious material so that it may do the least possible harm to respiratory function. Simple uninfected silicosis affects respiratory function in proportion to the amount of fibrous tissue that develops, the consequent reduction of vital capacity and the resultant failure of the right heart. The lungs of their experimental animals resembled those of old Cornish miners who were dyspneic and cyanotic as a result of strain on the right side of the heart.

If the lung becomes infected it increases fibrosis in the lung parenchyma around the nodules, produces ulceration and necrosis of bronchi and blood vessels and causes death of the animal from bronchitis, bronchopneumonia and empyema. The changes are similar to those seen in tuberculosilicosis in human beings or even in simple fibrocaseous tuberculosis.—*Audrey G. Morgan.*

CLEMENT, GAGE. Silicosis. *Radiology*, Oct., 1941, *37*, 407–412.

As a result of personal observation in the mines of the north central part of the United States, the author claims that simple silicosis is not a disease, it is not disabling and does not cause death. He says that silicosis does not predispose to tuberculosis. He presents roentgenograms which he claims support his contention. He says that silicosis causes no abnormal picture in the lungs except discrete nodulation and that any other abnormality is evidence of disease that is not caused by the silicosis.

Dr. Rigler said in the discussion that the extent of findings in the roentgenogram does not show the degree of disability in silicotics. He has seen 3 autopsies in the past three years in which the subjects had no evidence of any other pathological condition except silicosis and they died from this condition—or as he prefers to call it—this disease. He believes that silicosis does predispose to tuberculosis and cites the work of Lanza and the statistics of the Metropolitan Life Insurance Company in support of this opinion.—*Audrey G. Morgan.*

APFELBACH, GEORGE L., and CARTER, J. BAILEY. Recurrent postoperative atelectasis. *Radiology*, Nov., 1941, *37*, 598–603.

The first case of postoperative atelectasis reported was probably that of Barr in 1907. Elliott and Dingley in 1914 first put forth the theory that it is caused by obstruction of the bronchi by secretion. But there is considerable evidence against the truth of this theory. Cases have been described in which there was no obstruction of the bronchi, and a reflex via the vagus has now been suggested as the cause of this atelectasis. A case is described which lends support to this theory.

A first-stage Torek operation was performed on a boy of ten for cryptorchidism August 22, 1938. Eighty hours after operation his temperature rose to 104° F. and the diagnosis of atelectasis made from the clinical symptoms was confirmed by roentgen examination. He was made comfortable by postural treatment and his condition gradually returned to normal, though the atelectasis did not disappear completely for two weeks. On May 1, 1939, the second stage of the Torek operation was performed and because of the history the greatest care was used. The anesthetic was ethylene, as in the previous operation. On the fifth day after operation he showed weak, irregular pulse and high fever. The diagnosis of atelectasis was confirmed as before by roentgen examination. As before two weeks was required for complete disappearance of the atelectasis.

This case warrants a further study of the problem from the point of view of the vegetative nervous system with the object of using vagosympathetic block for the prevention of postoperative atelectasis.—*Audrey G. Morgan.*

Farber, Jason E. Bronchial stenosis and unexpandable lungs. *Am. Rev. Tuberc.*, June, 1941, *43*, 779–784.

Occlusion of a bronchus can be expected to produce atelectasis followed by irreparable pathological changes. This might result because of an ulcerative tuberculous tracheobronchitis and even because of a stenotic but non-occlusive peribronchial tuberculous process leading to pneumonitis and extensive fibrosis.

A case of the latter type is described. Bronchial asthma was the predominant symptom. Tubercle bacilli were isolated and a therapeutic pneumothorax was performed on the left lung. The clinical course was characterized by intermittent attacks of fever and episodes of copious expectoration with relief of toxicity. After several years of negative sputa, attempts were made to re-expand the lung but without success. Repeated bronchoscopic examinations revealed a bronchial opening of only a few millimeters at a site where there was considerable exudation.

A second case presented similar clinical manifestations with asthma and copious purulent expectoration. Tubercle bacilli could not be found in the sputum. Again, bronchoscopic examinations revealed a very minute lumen for the left main bronchus. Dilatation could not be accomplished.—*A. A. de Lorimier.*

Jacinto, Carmelo P., and Lahoz, Manuel. "Reversible" and "irreversible" massive pulmonary atelectasis: A radiologic study. *Radiology*, Nov., 1941, *37*, 588–597.

The authors made a roentgen study of massive pulmonary atelectasis at the Quezon Institute for Tuberculosis in Manila. They classify the cases as reversible or irreversible depending on whether or not it is possible for the lungs to be re-aerated. Reversible atelectasis is apt to be caused by blood clots or tenacious secretions in the bronchi while the irreversible type is largely caused by tracheobronchial tuberculosis, though it may occur suddenly during or after anesthesia.

The authors describe 4 cases and illustrate them with roentgenograms. They use serial teleroentgenograms or tomographic exposures in these cases; the latter are especially useful in differentiating between pleural and pulmonary opacities. About 5 mm. of the chest is within focus during each tomographic exposure and the plane in focus is pictured so clearly that it is easy to see the condition of the lung parenchyma.

Three of the cases reported were irreversible atelectasis, 1 of them non-tuberculous and caused by a bronchogenic tumor. Dyspnea was not a prominent symptom in these cases while in the 1 reported case of reversible atelectasis dyspnea was a very striking feature. This case was one of massive atelectasis of the entire lung in a Filipino. It was probably caused by blood clots after hemoptysis in tuberculosis. The dyspnea in this case was partially relieved by repeated insufflations of air into the left pleural cavity. Massive pulmonary atelectasis in Filipinos is not as rare as is generally believed. Of course it is harder to diagnose the reversible than the irreversible type because it is temporary. Cavities may occur in an area of atelectasis.—*Audrey G. Morgan.*

Israel, Harold L., and Long, Esmond R. Primary tuberculosis in adolescents and young adults. *Am. Rev. Tuberc.*, Jan., 1941, *43*, 42–55.

The age of onset of the primary phase of tuberculosis is changing, a larger and larger number showing lesions in adolescent or adult life. There appears to be a difference of opinion as to the seriousness of the lesions occurring at these later years. Some consider the resistance to be identical to that of childhood; others speak of

variations in the character of the lesions and much more serious prognoses.

Reference is made to the progressive changes as described in the second edition of "Diagnostic Standards"; in particular, to the most recent expression: "It is not always possible on clinical and roentgenological evidence to differentiate primary and re-infection phases of tuberculosis."

For this reason a number of cases of the Phipps Institute have been carefully studied with particular interest in the relationship of the tuberculin test to one or another type of lesion.

A relatively small proportion developed primary lesions during adolescence. Of those who did, it was very infrequent that clinical tuberculosis occurred within one year of the change from negative to positive skin reaction. In most instances, the time interval was greater than one year—thereby lending to the explanation that such cases represented a reinfection process.

A variety of types of lesion were found in those showing pulmonary changes within the one year of positive skin reaction—cases therefore considered as of the primary phase. The Negro group showed the greatest tendency toward lymphadenopathy, and the "typical" picture of childhood lesions. Lymph node enlargements among Negroes appear to be common regardless of the age of the individual

There was only 1 case of acute miliary tuberculosis. Loss of tuberculin sensitivity appears to be decreasing. The progress of lesions is frequently indeterminate, in 1 case a typical primary reaction leading to a progressive involution; in another, to a fulminating course. The majority of infiltrations appear to develop at least one year after the last negative tuberculin test.

The distinction between primary and reinfection disease will rarely be a useful guide in estimating prognosis or in planning treatment for the individual case.—*A. A. de Lorimier.*

ACKERMAN, LAUREN V., and KASUGA, KAZUMI. Chronic cor pulmonale; its relation to pulmonary tuberculosis. *Am. Rev. Tuberc.*, Jan., 1941, *43*, 11–30.

Acute cor pulmonale is usually caused by a large pulmonary embolus or it is secondary to disease of the left heart. It is characterized by sudden onset of cyanosis, low blood pressure and possibly by a state of actual shock. The manifestations may simulate acute coronary occlusion or spontaneous pneumothorax. Roentgenographically, there can be expected to be evidence of dilatation of the pulmonary arteries and enlargement in the region of the conus.

Subacute cor pulmonale has been considered as identical to these. However, Brill has suggested that the subacute type is due to plugging of the lymphatics of the lung such as might be produced by metastatic carcinoma arising from the stomach. It is theorized that such plugging may cause irritation about the contiguous pulmonary arteries with resultant formation of small thrombi and hypertension in the pulmonary circulation.

Chronic cor pulmonale may be secondary to left sided failure or it may be due to changes in the arterial system of the lung or to alterations in the pulmonary parenchyma or thoracic cage. The first of these is the most common, the changes being secondary to aortic insufficiency, mitral stenosis, coronary disease and even to beri-beri, etc. As far as changes in the vascular bed are concerned, thromboses may occur in sickle cell anemia, primary sclerosis, necrotizing arteritis, etc. Alterations in the parenchyma include bronchiectasis, silicosis, bronchogenic carcinoma or any other disease of widespread involvement.

This report is concerned particularly with the chronic type and especially with pulmonary tuberculosis as the contributing factor. The incidence of hypertrophy of the right heart has been reported variously by different observers—from less than 0.1 per cent to as high as 33 per cent in cases of pulmonary tuberculosis.

Identifying symptoms may be meager. Roentgenography should include posteroanterior, oblique and lateral projections. The electrocardiogram may show right axis deviation or no abnormality. Diodrast injections may be most informative. Tomography may be informative. In early cases the use of ether and decholin or other drugs may be indicated to establish prolongation of the circulation time from the arm to the lung. In the more advanced cases there may be paroxysmal nocturnal dyspnea with Cheyne-Stokes breathing, cyanosis, distention of cervical veins, enlargement of the liver and spleen, ascites and edema of the lower extremities.

Pathologically, the wall of the right ventricle may be found to measure as much as 5 mm. in thickness. It may even be thicker than the left

ventricle. The heart may weigh 250 to 500 grams. The pulmonary arteries may show periarterial fibrosis and atherosclerosis or subintimal fibrosis, atrophy of the media and increase in the elastic tissues of the intima and adventitia.

Of a group of 330 autopsies concerned with patients of the San Francisco City and County Hospital, 16 per cent showed cor pulmonale. Obliteration of pleural space was of frequent incidence among the entire group though it did not seem to be a definite factor.

The existence of this condition should be considered before instituting any type of collapse therapy for the added embarrassment of collapse may result in sudden or early death.

Death occurs earlier in cases of tuberculosis complicated by silicosis or anthracosilicosis as compared with cases of any one of these conditions, alone. Heart failure is the common terminal factor.

In chronic miliary tuberculosis there may be a diffuse fibrosis through the interstitial tissues with right heart enlargement but more commonly a miliary lesion is too rapid in development to present the heart changes.

The authors conclude that the evidence of cor pulmonale is relatively low in uncomplicated pulmonary tuberculosis. It tends to develop in a chronic productive tuberculosis of long standing where there is a secondary emphysema; in chronic productive miliary tuberculosis and in pulmonary lesions complicated by silicosis or anthracosilicosis. Pneumothorax or long standing and markedly thickened pleurae may produce it, as may also thoracoplasty. The existence of other cardiac pathologic conditions can be expected to hasten the development of it.—*A. A. de Lorimier.*

Koerth, C. J., Donaldson, J. M., Jr., and McCorkle, R. G. Bronchomoniliasis. *Am. Rev. Tuberc.*, June, 1941, *43*, 723–737.

In 1905, Castellani described primary bronchomoniliasis in a "tea taster" of Ceylon, India. Subsequent reports indicate a substantial incidence of such infection. Keiper, for instance, estimates that 3 per cent of apparently normal individuals harbor monilia in their throats and that 2.93 per cent of pulmonary disease is due to these organisms. It is more common in tropical and subtropical climates but masquerades as tuberculosis in all latitudes.

Two such cases are reported in detail.

The diagnosis is dependent upon isolating the organism from sputum which is definitely expectorated from the lungs. The mouth should be cleansed well prior to collecting a specimen. Usually a culture is necessary. The value of inoculation of the isolated organism into animals such as the rabbit is disputed. Skin testing with such organisms appears to be of greater reliability. Agglutination tests are believed to be impractical. Complement fixation tests may be indicative. Particularly in cases which have developed an allergy to the monilia, there may be an appreciable eosinophilia.

Roentgen studies may be negative or they may show peribronchial thickenings, areas of infiltration, consolidations, fibrosis, pleural thickening or scattered nodules throughout the lung fields. The criteria of pulmonary tuberculosis may be duplicated except that in monilia involvements of the lung, the apices are usually clear. Moreover, in the latter, the lesions are likely to manifest migratory tendencies.

Pathologically, there may be found consolidations, cavitations, fibroses and tubercles. Microscopically, the alveolar walls may appear thickened, the tubercles may show a caseous center surrounded by epithelioid cells, lymphocytes and an occasional giant cell.

Treatment consists of potassium iodide given in dosages of 5 drops, three times a day, increased as tolerated up to 30 drops three times a day. Of course, tuberculosis should be ruled out before instituting such treatment. The iodide therapy may be supplemented by subcutaneous injections of autogenous vaccines. Other treatment includes pix liquida (1 gram or more a day), thymol (given orally), gentian violet or methylene blue (given intravenously). Roentgen therapy has given fair results. Intratracheal and intramuscular injections have been recommended for severe cases.—*A. A. de Lorimier.*

Singer, J. J., and Tragerman, L. J. Lipoid pneumonia; report of a case simulating bronchial carcinoma. *Am. Rev. Tuberc.*, June, 1941, *43*, 738–747.

Oil pneumonias are of interest particularly because of the bizarre pictures which they may produce and because they are so seldom suspected. They are found especially during the first months or years of life and in old age or in the very debilitated.

The case reported is of a physician who for several years had been taking mineral oil be-

cause of constipation. The disease picture was considered a pulmonary cancer. His trouble developed with a coronary attack following which he had experienced difficulty in swallowing. At intervals, he became febrile and expectorated blood streaked sputum. Roentgenography of the chest prompted a diagnosis of lymphatic carcinomatosis. One consideration was of silicosis. Because of loss of weight, hemoptysis, weakness and pain over the chest, carcinoma seemed the more likely. After a period of three years he had lost 66 pounds. He could not sleep and he suffered marked dyspnea. Various studies were refused because the doctor had been told that he had a carcinoma and he was certain of the diagnosis.

During the last year, he developed ascites, anasarca and right heart failure—secondary to emphysema, bronchiectasis and diffuse pulmonary fibrocystic changes with multiple abscesses. His temperature reached 104° F.

The authors emphasize that though there be no known treatment for lipoid pneumonia, it is important that the administration of oils be discontinued as early as possible. This case, along with others, emphasizes the importance of accomplishing a complete study in all chest problems. Lipoid pneumonia should be suspected whenever there is a dysphagia in one using oil. The presence of oil droplets in the sputum may support the diagnosis though such evidence may be lacking unless bronchoscopy is accomplished.—*A. A. de Lorimier.*

THOMAS, A. ROBINSON. "Blast chest"; radiological aspect of the pulmonary changes following exposure to high pressure waves. *Brit. J. Radiol.*, Dec., 1941, *14*, 403–406.

Cases of what is called "blast chest" are described and illustrated with roentgenograms. They are caused by waves of high pressure from explosives and a number of them have been seen since the beginning of the war. The chief roentgen finding is an opacity of the lung, which varies in degree depending on the severity of the lesion. The ribs over the affected area are crowded together behind and widely separated in front, that is they are in a position of hyperexpansion. It is hard to get good roentgenograms of these cases as the patients are usually confined to bed and often have severe burns or lacerations so that they have to be examined in bed with portable apparatus. There are few clinical signs in mild cases except a ballooning due to the hyperexpansion. The opacity is caused by hemorrhage into the lung, and therefore it is important for physicians to know that roentgen examination should be done in these cases, as otherwise serious injuries may go undetected.—*Audrey G. Morgan.*

CRIMM, PAUL D., COOKSON, H. N., and BROADBENT, M. Patch and PPD tests and x-ray correlation. *Am. Rev. Tuberc.*, June, 1941, *43*, 799–805.

In an Indiana section 1,556 high school freshman were studied with patch tests, intracutaneous tests and roentgen examinations. The intracutaneous testing was made with a dosage of 0.001 mg. as the routine. The injections were made in the left arm and the patch tests were applied to the right arm (after cleansing and defatting with acetone). Readings were made after forty-eight hours and again after seven days. The intracutaneous tests were reported positive when there was redness with induration. The patch test was considered positive in the presence of follicles on an erythematous indurated base.

The incidence of contact was 10.7 per cent; 29.9 per cent showed positive evidence roentgenologically or by one or the other skin tests. There were no definite cases of reinfection though 7 showed some fibrosis; 15.8 per cent were positive to the patch test; 16.3 per cent, to the intracutaneous inoculation. Fourteen were negative to the patch test and positive to the intracutaneous test while 7 were positive to the patch test and negative to the intracutaneous test.

Considering the entire group which showed evidence of one sort or another, the 29.9 per cent, 19.7 per cent showed positive roentgen evidence; 16.7 per cent, positive tuberculin testing; 6.2 per cent were positive both to roentgen ray and the tuberculin; 13.2 per cent were negative to both tuberculins but showed positive roentgen evidence; 10.2 per cent were positive to the tuberculins and negative roentgenologically. Sixty-five and nine-tenths per cent of the total group who showed any positive evidence showed roentgen evidence while 56 per cent were positive to the tuberculins—an efficiency for roentgen examination over the tuberculins of 9.9 per cent.

Previous studies of an adult group indicated that tuberculin testing was 2.2 per cent more effective than roentgen examination. The effi-

ciency of the tuberculin test increases up to the age of fifty years when it decreases due to probable loss of allergy. Re-examinations with higher dosage of P.P.D. (0.005 mg.) increased the efficiency 3.6 per cent.

The authors conclude that the patch test may safely supplant the intracutaneous test although they admit difficulty of reading the former in colored subjects.—*A. A. de Lorimier.*

Gowar, F. J. Sambrook. The post-operative complications of pulmonary lobectomy; clinical and experimental study. *Brit. J. Surg.*, July, 1941, *29*, 3–18.

In spite of improvements in surgical technique pulmonary lobectomy for bronchiectasis still shows a mortality of 10 to 20 per cent. In an attempt to determine the causes of the complications following this operation and if possible find means of preventing them, the author reviews 154 cases operated on at the Brompton Hospital from 1929 to 1938.

The complications that may occur are shock, reactionary hemorrhage, tension pneumothorax, embolism, intracardiac thrombosis, massive collapse of the remaining lobe, bronchopneumonia, infection, pericarditis and spread of the bronchiectasis. Collapse of the remaining lobe is by far the most serious complication and was responsible for more than one-third of the post-operative deaths in this series. Illustrative roentgenograms are given. Collapse occurs much more frequently if the lobe is free and therefore the best means of preventing it is to bring about adhesions between the upper lobe and the chest wall. This can be done by insufflating iodized talcum powder into the pleural cavity. This method is harmless if the powder is efficiently sterilized. The ideal time for operation is three to eight weeks after the insufflation while the adhesions are still soft.

Other precautions that may be used to decrease the danger of lobectomy are: allowing a long period of postural drainage after operation in order to reduce the amount of sputum; encouraging the elimination of the contrast medium after bronchography, and, if there is much roentgen evidence of retention, allowing an interval of at least two months between bronchography and lobectomy; using spinal anesthesia; provision of adequate drainage and taking care to see that it does not become blocked; encouragement of postural drainage of the upper lobe by placing the patient in a semi-sitting position as soon as possible after the operation; encouragement of re-expansion of the upper lobe by breathing exercises and if necessary by intermittent inhalations of CO_2 and oxygen.—*Audrey G. Morgan.*

Gengenbach, F. P., and Dobos, E. I. Congenital tracheoesophageal fistula. *J. Pediat.*, Nov., 1941, *19*, 644–655.

Tracheoesophageal fistula is usually found in association with atresia of the esophagus. These fistulae invariably occur at or close to the bifurcation of the trachea. Embryologically the trachea and esophagus appear to arise from a common entodermal pouch situated in the thorax behind the heart. Lateral grooves appear in this pouch when the embryo has reached a length of 4 mm. and these eventually meet in the center to form a septum which divides the entodermal pouch into a posterior tube belonging to the alimentary system and an anterior tube belonging to the respiratory system. Tracheoesophageal fistulae represent incomplete development of this septum.

Vogt has divided congenital atresia of the esophagus into three types: (*a*) complete absence of the esophagus; (*b*) the esophagus is divided into an upper and lower pouch with no communication, and (*c*) cases with fistulous tracts between the esophageal pouches and the trachea.

The diagnosis of tracheoesophageal fistula has been made by injecting barium, or better iodized oil, into the esophagus through a small catheter. Recently Lanman has advised that this is potentially harmful and unnecessary. He feels that the diagnosis can be made by inserting a soft rubber catheter into the esophagus and exposing a film. The only hope for ultimate survival of the infant lies in surgery in the first few days of life. Otherwise an aspiration pneumonia is certain to result.

The author concludes his article with case reports of 10 infants. In the majority the diagnosis was made or at least suggested by roentgen examination following barium or iodized oil ingestion.—*R. M. Harvey.*

Sachs, Maurice D. Carcinoma of the male breast. *Radiology*, Oct., 1941, *37*, 458–467.

A questionnaire on carcinoma of the male breast was sent to a large number of pathologists, radiologists and surgeons in the United States and Canada and records of 208 cases

were collected with pathological data in 178. In addition to these cases 172 from the literature were analyzed.

In this series the ratio of male carcinomas to all carcinomas in the male was 0.38 per cent and that to cancers in the female breast 1.32 per cent. The average age was 57.17 years, the youngest patient being twelve years of age and the oldest eighty-six years. The average in the male is older than in the female. The average time between the beginning of symptoms and the first consultation of a physician was 1.14 years. Sixty-one per cent of the patients consulted a doctor within a year of the beginning of symptoms and 87.2 per cent within two years

There was retraction of the nipple in 33.1 per cent of the cases, pain in 38.1 per cent, bleeding nipple in 14.6 per cent, ulceration in 20.6 per cent; there was a history of trauma in 23.9 per cent of the cases. The carcinoma was bilateral in 3 cases, in the right breast in 99 and in the left breast in 103.

The histopathological findings are practically the same in cancer of the male breast as in that of the female breast. The prevailing types are adenocarcinoma, scirrhous carcinoma, medullary carcinoma and carcinoma simplex. Sarcoma, squamous cell and basal cell carcinomas are rare. Wainwright said that he could not differentiate in histopathological studies between male and female carcinoma.

There was local recurrence in 25.9 per cent of these cases, distant metastases in 46.3 per cent. Postmortem examinations were done in 24 of this series of cases and 17 from the literature. They showed metastases in the lungs in 62.5 per cent, in the ribs and axillae 29.17 per cent, pleura 33.33 per cent, spine 25 per cent, pelvis and generalized metastases 20.83 per cent.

Simple mastectomy was performed in 21 per cent of the author's cases, total mastectomy in 44 per cent. Roentgen treatment was given in 53 per cent. Among these cases 23.8 per cent were given preoperative roentgen treatment, 55.1 per cent postoperative and 21.1 per cent palliative treatment.

The prognosis is bad in cancer of the male breast. Fifty-two per cent of these patients were dead within five years, though most of them had been given adequate surgical and roentgen treatment; 7.5 per cent were living and well at the end of that period; 7 per cent were living with recurrence after from five to ten years; 3 per cent were living and well after ten to fifteen years and 2.9 per cent were living after from sixteen to twenty years.—*Audrey G. Morgan.*

KORNBLUM, KARL, and BRADSHAW, HOWARD H. Intrathoracic neurogenic tumors. *Radiology*, Oct., 1941, *37*, 391–406.

Intrathoracic neurogenic tumors are commonly believed to be quite rare but the authors have seen 7 cases within the past four years in addition to one malignant metastasis which was mistakenly diagnosed as a neurogenic tumor. The only clinical symptoms from these tumors are pressure symptoms and their nature depends on the organs on which pressure is being exerted. They are of little value in diagnosis. A rapid course and marked loss of weight suggest malignancy. The most valuable method of diagnosis therefore is roentgen examination and many of these tumors are discovered accidentally on routine roentgen examination.

The authors' 7 cases, consisting of 4 neurofibromas and 3 malignant neurogenic tumors, are described and characteristic roentgenograms given. In only 1 of these cases was the correct diagnosis made by roentgen examination, and yet the appearance is so typical that diagnosis should not be difficult. Most of them are in the posterior part of the chest and a dense, rounded, well circumscribed shadow in the posterior part of the chest of considerable size should suggest such a tumor. It is remarkable to what a large size they can grow without causing clinical symptoms. A fluoroscopic examination should first be made with the patient in all possible positions in order to show the effect of the tumor on respiration and heart action and the position of the diaphragm and its movements. Roentgenograms should be taken in anteroposterior, lateral and oblique positions. As neurogenic tumors are generally in the posterior part of the chest the lateral view is particularly important. Stereoscopic films are often of value. Films made with the Potter-Bucky diaphragm should be a part of the routine examination. The use of iodized oil is not of much value but an examination after artificial pneumothorax often gives valuable information.

The only treatment is surgical. These tumors are very resistant to irradiation and therefore in benign cases roentgen treatment is of no value. In malignant cases it may relieve the symptoms. In 2 of the authors' cases of neurofibroma the surgical results were excellent, in 1

the patient died suddenly from peritoneoscopy and in 1 of neurofibroma of the esophagus the patient died four days after operation. Diagnosis is difficult in such unusual sites.—*Audrey G. Morgan.*

Odessky, I. N. The roentgen diagnosis of neurinoma of the thorax. *Radiology*, Oct., 1941, *37*, 454–457.

The author reports from Moscow a case of neurinoma of the wall of the chest in a woman of thirty-seven who had been sent in with a diagnosis of echinococcus cyst of the lung. Roentgen examination showed an oval homogeneous shadow in the upper part of the left lung measuring 7×4 cm. close to the chest wall. It appeared to lie outside the lung which was otherwise unchanged. There was no interference with the excursion of the diaphragm. On the basis of the clinical and roentgen findings a probable diagnosis of encapsulated exudative pleurisy was made. Operation showed a tumor which histological examination proved to be a neurinoma.

These tumors of the chest wall are rare. The roentgen appearance may resemble that of encapsulated pleurisy or metastatic tumor. If the roentgen picture remains constant over a long period and the patient's general condition is good it suggests neurinoma. If there are neurofibromatous lesions of the skin or elsewhere it supports this diagnosis.—*Audrey G. Morgan.*

McGibbon, John E.G. and Baker-Bates, E.T. A bronchoscopic clinic. *Brit. J. Surg.*, Jan., 1941, *28*, 404–414.

The authors, who are laryngological surgeon and physician to the Royal United Liverpool Hospital, established a bronchoscopic clinic six years ago. It has been held once weekly and it has been found that the maximum number of patients that can be examined at a session of four. Up to the outbreak of the war they had performed 937 bronchoscopic examinations, on 581 patients, 442 males and 139 females. The findings were negative in 130 cases, or 22.4 per cent. The compilation of full notes on all cases, careful follow-up of the patients and autopsies when possible have proved valuable features of the work.

The bronchoscope used, which is illustrated, was designed by McGibbon. The chief symptoms for which patients have been sent for examination are hemoptysis, dyspnea, pulmonary collapse, suppuration of the lung, pneumonitis and so-called unresolved pneumonia and suspected bronchial neoplasm. The findings have been diverse and often surprising. Of the total 581 patients, 222 presented hemoptysis and a diagnosis of tuberculosis had been made in many of these cases. Simple new-growth was found in 13 of these cases and malignant new-growth in 119.

The therapeutic measures used through the bronchoscope include removal of foreign bodies, drainage of suppurative lesions by suction, lavage of bronchiectatic and abscess cavities, installation of antiseptics, dilatation inflammatory strictures, removal of granulations and simple and malignant tumors, diathermic coagulation of tumors, insertion of tube containing radon seeds and interstitial insertion of radon seeds.

The authors believe that bronchoscopic clinics are necessary but that too many of them should not be established or they will not get the large numbers of patients necessary for the broadest experience. A bronchoscopic team must include a physician, a radiologist, a laryngologist, a thoracic surgeon and trained assistants. —*Audrey G. Morgan.*

Douglas, Bruce H., and Birkelo, Carl C. The miniature x-ray film of the chest. *Am. Rev. Tuberc.*, Jan., 1941, *43*, 108–116.

Photoroentgenography is recommended for the study of large groups because it is economical. It is an effective method of case finding without collaborative skin testings. With the use of the 4 × 5 inch film, direct viewings are practical and they have been found to be sufficiently accurate. They are practical by providing a record with one examination—not provided with a procedure such as where the subject may fail to return for checking of the reaction. Standard film studies with or without the use of a Potter-Bucky diaphragm, or laminectomy may be indicated for special cases, the miniature film roentgenography being considered essentially a survey procedure and not a substitute for the finer problems of diagnosis of chest diseases. However, among 6,104 consecutive examinations, large film studies were called for in only about 0.8 per cent.—*A. A. de Lorimier.*

Faulkner, William B., Jr., Rodenbaugh, F.H., and O'Neill, John R. Influence of the emotions upon esophageal function: A comparison of esophagoscopic and roentgenologic

findings. *Radiology*, Oct., 1941, *37*, 443–447.

Physicians have not been inclined to accept the belief of psychiatrists that emotional disturbance can produce symptoms that cannot be distinguished from those of organic disease. But the authors describe cases in which roentgen examination definitely showed spasm of the esophagus under the influence of unpleasant emotions brought on by suggestions on the part of the physicians themselves, the spasm disappearing completely when happier emotions were restored by the suggestion of pleasant subjects. This possibility of spasm being produced by emotion should be borne in mind in examining the esophagus. An esophagoscopic examination should be made in such cases to be certain of excluding any form of organic disease, such as stricture, ulcer, cancer or other pathological condition.—*Audrey G. Morgan.*

ABDOMEN

Davidson, S. Whately, and Rose, J. Dudfield. The value of co-operation between the radiologist and gastroscopist. *Brit. J. Radiol.*, Oct., 1941, *14*, 307–319.

The authors emphasize the standpoint that gastroscopy and roentgenology should not be considered rival methods but complementary to each other. If roentgen examination were made first, followed by gastroscopy, the necessity for exploratory operation would be greatly decreased. Finer changes in mucosal relief can be detected by gastroscopy than by roentgenology and an accurate knowledge of the condition of the submucosal and muscular layers can also be obtained. The fundus and greater curvature of the stomach can be demonstrated more easily by gastroscopy than by roentgenology, but it is hard to see the cardiac opening, the highest part of the lesser curvature, a small part of the posterior wall, the most medial part of the fundus and the lowest part of the greater curvature by gastroscopy.

During the past two years gastroscopic examinations have been made in 6,000 cases at the Royal Victoria Infirmary and roentgen examinations have been made in 256 of these. In 39 cases a roentgen diagnosis of carcinoma was confirmed by gastroscopic examination, but in 37 it was refuted. If both forms of examination had not been made exploratory laparotomy would have been necessary in the latter cases. In 7 cases in which the roentgen report was negative for cancer it was positive on gastroscopic examination. Thirty-nine cases of ulcer reported by roentgen examination were confirmed gastroscopically, 7 were refuted and 4 with negative roentgen reports were found positive on gastroscopic examination. Two cases of polyps found on roentgen examination were confirmed gastroscopically, but 2 reported negative roentgenologically were positive gastroscopically. In 1 case a roentgen diagnosis of extragastric tumor was changed to one of cancer of the stomach on gastroscopic examination. In only 1 case did gastroscopic examination fail to show a cancer later found on operation. This cancer would probably have been demonstrated by roentgen examination, which was not performed on account of lack of time.

A much more accurate knowledge of the gastric mucosa is being developed by close cooperation between gastroscopist and roentgenologist. —*Audrey G. Morgan.*

Taylor, Hermon. Practical evaluation of gastroscopy. *Lancet*, Feb. 1, 1941, *1*, 131–135.

The flexible gastroscope was first used at the London Hospital in September, 1935. From that time to September, 1939, it was used in 350 cases of dyspepsia. Of these 32 were found to have normal stomachs. In 26 cases (7 per cent) the examination could not be completed, the most frequent cause being inflammatory lesions high up on the lesser curvature. There were local lesions in 112 cases, 34 of these being carcinoma. Small tumors that had not been diagnosed clinically were found in 14 cases and carcinoma was excluded in 68 cases in which it had been suspected clinically. In at least 25 of these cases exploratory laparotomy would have been necessary if gastroscopy had not been carried out.

In a series of 321 cases of carcinoma admitted to the hospital during these years the operability was only 17 per cent in the cases diagnosed without gastroscopy and 68 per cent in those diagnosed by gastroscopy. Both ulcer and cancer can be detected earlier with gastroscopy than without it. The two-view gastroscopic test is valuable. The patient is gastroscoped and an ulcer found. He is put on medical treatment for three weeks and another gastroscopy performed. If there has been healing the ulcer is benign; if there has been no change or progression it is malignant. Among 22 cases in which this test was used 8 ulcers supposed to be benign were found malignant and 14 thought to be malignant were found benign. The so-called thera-

peutic test for malignancy without gastroscopy is not reliable. Cancer is often accompanied by gastritis and the treatment heals the gastritis but without curing the malignant growth. Gastroscopy will show the malignant lesion in these cases. Patients with dyspepsia should be taught to come for gastroscopic examination.

Gastroscopy is useful in following up ulcer treatment also. Frequently both patient and physician are inclined to give up treatment after a negative roentgenogram but gastroscopy may show persistence of the ulcer.

Normal individuals may have various types of gastric mucosa—average, hyperplastic or hypoplastic. Disease is much more apt to occur in the hyperplastic and hypoplastic types. Acidity is not a reliable indicator of the type or condition of the gastric mucosa. This can be determined only by gastroscopy. A gastric juice with normal or even subnormal acidity may break down a mucosa depressed by chronic inflammation.

Gastroscopy has shown that ulceration occurs after gastroenterostomy if there is excessive hyperplasia of the mucosa. The recurrent ulcer is attributable not to the operation but to the type of mucosa. Therefore gastroscopic examination is of value in determining the cases in which gastroenterostomy should be performed and those in which the operation should be partial gastrectomy. And if gastrectomy is performed it must be extensive enough to prevent recurrent ulceration.

A wider use of gastroscopy would decrease the mortality from cancer of the stomach and the morbidity from gastritis and peptic ulcer. —*Audrey G. Morgan.*

White, J. Duncan. An unusual sequel to gastroscopy. *Brit. J. Radiol.*, Nov., 1941, *14*, 364–365.

A case is described in which gastroscopy was performed in a man of fifty-eight because of symtoms of duodenal ulcer and gastritis. The instrument passed without any difficulty, but four days later the patient had fever and dysphagia and roentgen examination showed that the esophagus had perforated and a retropharyngeal abscess had developed. This is unusual when there is no difficulty in the passage of the gastroscope. Probably the instrument caused a slight abrasion of the mucosa which became infected from the esophagus.—*Audrey G. Morgan.*

Colmers, Rudolf A. Parasternal diaphragmatic hernia with report of a case on the right side. *Radiology*, Dec., 1941, *37*, 733–739.

A case of right parasternal diaphragmatic hernia is reported in a woman of seventy-seven. Autopsy showed a loop of the transverse colon, part of the great omentum and the upper part of the round ligament of the liver herniated into the right side of the thorax through the foramen of Morgagni. The middle lobe of the right lung was atelectatic and reduced to a thin strip of tissue. It contained a calcified nodule, apparently a healed focus of primary tuberculosis. There was coal pigment in the lung and elastic fibers in the walls of the alveoli. The patient had had no symptoms referable to the hernia until after she was forty years of age.

This case seems to support the theory that these parasternal herniae develop during adult life. The patient had the type of constitution that predisposes to parasternal hernia. The elastic fibers in the walls of the alveoli prove that it developed after birth and the coal pigment in the atelectatic lobe suggests that it appeared during adult life.

Because of the high incidence of strangulation in these cases operation should be performed unless there are strict contraindications. Roentgen examination is useful in diagnosis. If the colon is in the hernia the haustration is often visible. If omentum or gut filled with feces is in the hernia there is a rounded shadow free of the lung and continuous with the diaphragm. Differential diagnosis from tumor may be difficult. In this case, as well as in one described in the literature, the roentgenogram suggested interlobar fluid. The attending physician in that case recommended paracentesis, which if it had been performed would probably have been fatal.— *Audrey G. Morgan.*

Delano, Percy J., Ronayne, Frank J., and Boland, Thomas B. Rectal dyschezia: a misnomer for megarectum. *Radiology*, Dec., 1941, *37*, 730–732.

A case of enormously dilated rectum filled with masses of feces is described in a woman of twenty-seven. She had suffered from this condition since childhood. It has commonly been called rectal dyschezia and has been attributed to strictures and atresia above the dilated segment. The authors believe, however, that it is caused by anomalies in sympathetic innervation and that the name rectal dyschezia should be given up and that of megarectum substituted.

A number of selected cases in which sympathectomy has been performed seem to support this theory. The cases must be selected because if the condition is of very long standing the wall of the intestine can no longer respond to a correction of its innervation. The best way to determine before operation whether it is capable of response is by the use of spinal anesthesia and parasympathetic drugs.—*Audrey G. Morgan.*

WASSON, W. WALTER. Study of the gastro-intestinal tract of children and its relation to the adult. *Radiology*, Sept., 1941, *37*, 277–283.

Some roentgen studies have been made of the gastrointestinal tract of infants and very young children, but not nearly so many as of adults. Very few have been made in the older child and adolescent, probably because there are few diseases at this age.

There are certain differences in the gastrointestinal tract of the infant and adult that seem to be of significance. In the infant the only point of delayed transmission of food is in the stomach, in the adult in the colon. In the adult emptying of the colon may require twenty-four to forty-eight hours longer than in the infant. The mucous membrane of the infant's digestive tract is delicate and the sphincters are not developed as they are in the adult. With advancing age the contractions of the stomach and intestines become stronger and the angulation of the flexures sharper. There is a change of some of the organs from a recumbent to an upright position. Because of the slowing of the progression of the food in the colon and to a lesser degree in the small intestine in the adult, the roentgenogram shows a different pattern. In the infant the upper parts of the small intestine show an irregular globular pattern while in the adult they have a typical snow-flake appearance. The outline of the colon becomes sharper in the adult with more complete filling and more pronounced haustral markings. The appendix of the infant and young child is seldom visible while lack of such visibility in the adult is considered a sign of disease.

The author suggests that systematic studies should be made of the gastrointestinal tract at different ages and that in this way it might be possible to prevent some of the diseases of adult life by correcting functional defects in children. This could be done by studying groups at different ages or by following a single subject through life. The latter method would require that the younger roentgenologists take up the systematic study of the gastrointestinal tract with regard to anatomy and function as well as with regard to disease.—*Audrey G. Morgan.*

RITVO, MAX, and MCDONALD, EUGENE J. Gastrocolic fistula: report of twelve cases. *Radiology*, Sept., 1941, *37*, 269–276.

Gastrocolic fistula is rather uncommon, but it is of great clinical importance because if prompt surgical aid is not given it causes death in a comparatively short time. The most common causes are peptic ulcer, cancer of the stomach and cancer of the colon. Cases caused by cancer have decreased because of better surgical treatment but those caused by peptic and jejunal ulcer have increased because of the increased frequency of posterior gastroenterostomy.

Gastrocolic fistula occasionally begins acutely. Any sudden change in the symptomatology after posterior gastroenterostomy should suggest the possibility of its occurrence. Ordinarily, however, the beginning is gradual and the chief symptoms are loss of weight, nausea, diarrhea, and fecal vomiting. But it is difficult or impossible to make a diagnosis for the clinical symptoms alone. The only means of absolute diagnosis is by the roentgen demonstration of the abnormal opening between the stomach and colon. Sometimes the diagnosis is made by means of a barium meal, sometimes by a barium enema.

The authors discuss 12 cases from the records of the Boston City Hospital. Seven of these followed posterior gastroenterostomy, 3 were caused by carcinoma of the stomach, 1 by cancer of the colon and 1 by a tumor of unknown origin. Eleven of these cases were in men and only 1 in a woman.—*Audrey G. Morgan.*